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The Marine Terminal of the Grand Trunk Pacific Ry., Prince Rupert, B. C.*

By Frank E. Kirby and William T. Donnelly†

When, in 1910, the authors of this paper were retained to visit the Pacific Coast for the purpose of studying the shipping and marine-repair facilities and to visit Prince Rupert, the western terminus of the Grand Trunk Pacific Ry., they were at a loss how to proceed, for not only was Prince Rupert beyond their geographical knowledge, but it also failed to appear upon any available map or chart.

Finally proceeding from Vancouver on the Canadian Pacific steamer northward through the inland passage, after three days' steaming through the narrow waterways which were literally the submerged valleys of the Coast Range, they arrived on the evening of the third day in the harbor of Prince Pupert.

On recent charts of the Northern Pacific and Alaskan coasts, Dixon's Entrance, north of Graham Island between 54° and 55° north latitude, can be readily located. To the east of Dixon's Entrance, Brown Pass leads to Chatham Sound and across this to the east, between Digby and Kaien Islands, is found Prince Rupert Harbor. So hidden away and unprepossessing is the entrance that until 1906 it was supposed to be unnavigable. Actual surveys show it to be one of the most easily entered and satisfactory harbors on the Pacific Coast. The entrance, which is from the south, is about three-eighths of a mile wide. It is entirely unobstructed, with a depth of water nowhere less than 20 fathoms.

The city of Prince Rupert is located on Kaien Island which forms the south-harbor front of Kaien Island determined Hays Cove as the only practical place for such a development as was contemplated; that is, (1) a floating drydock of 20,000 tons lifting capacity, so designed as to be capable of operating in section as a number of smaller docks, (2) an adequate shore plant comprising an electric power-generating plant, compressors, machine shop, boiler and blacksmith shop and covered construction shed under which the pontoons of the floating drydock could be built.

The dock is to be of such a design and construction as to be almost entirely built upon the site. To accomplish this,

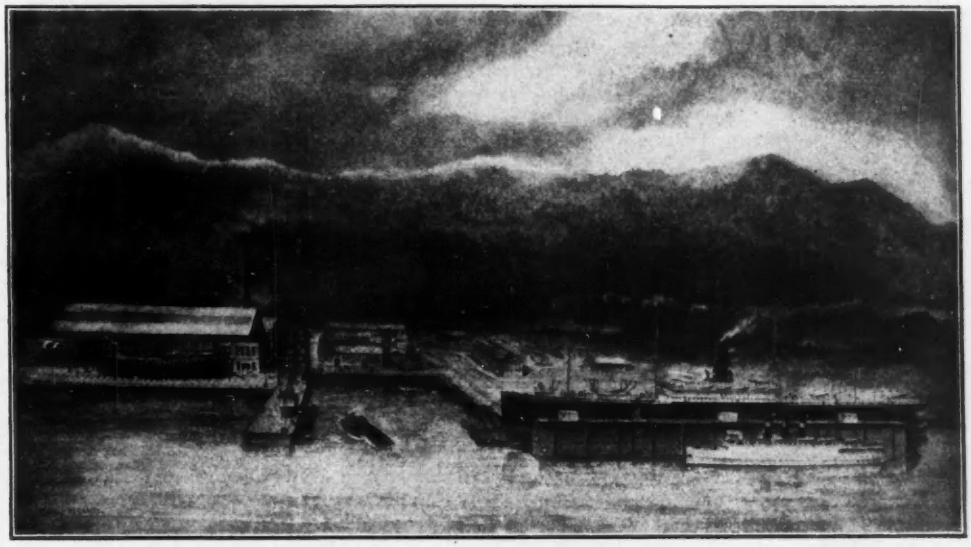

Fig. 1. The Proposed Prince Rupert Marine Terminal, Grand Trunk Pacific Ry.

east shore of Prince Rupert Harbor. The city proper is laid out over an area 3½ miles in length by one mile in breadth, on the shore of the island, with a background rising to an elevation of from 1600 to 2000 ft., the general characteristics reminding one very forcibly of the city of Montreal with Mount Royal behind it.

The Grand Trunk Pacific Ry. will reach the coast by the Skeena River valley, about 15 miles to the south and, crossing to Kaien Island at its southern end, will closely follow the shore to and along the water front of Prince Rupert.

The general character of the shore of Prince Rupert is bold and rocky, falling off very rapidly to a depth of approximately 20 fathoms. A careful examination of the entire length of the

the general plan provides for the practical completion and equipment of the shore plant before the drydock is commenced.

One of the controlling features in the general plan of this development was the fact that the city of Prince Rupert will be 600 miles from the nearest base of supply or point where any considerable assistance, mechanical or otherwise, can be obtained. It was therefore determined at the outset that the mechanical equipment, large tools, etc., must be of the very best and most complete. Also, that on account of the high price of labor on the Pacific Coast, ample provision for the use of power in every way possible should be made. This has resulted in the design of an electric power-generating station with ample capacity for

*Brief abstract of a paper presented before the eighteenth annual meeting of the Society of Naval Architects and Marine Engineers, New York City, Nov. 16, 1911. Copyrighted. Used by permission.

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all present needs and with a large possibility of extension.

PIER AND PLATFORM WORK—The first work to be undertaken will be the pier 420 ft. long and 60 ft. wide, the piling being on 10x5-ft. centers. At the same time, there will be built the platform at the shore end of this pier, 80 ft. wide by 930 ft. long. At the western end of this platform there will be an extension off shore 350 ft. long by about 100 ft. wide and, at right angles to this, an extension 560 ft. long by 80 ft. wide for the attachment of the floating drydock. A double line of diagonal bracing is used in the pile work, on account of the excessive rise and fall of tide at Prince Rupert, which for spring tide is 25 ft. The tops of the piles are thoroughly secured by double 6x12-in. clamps and connected by 12x12-in. caps. The decking is to be of 4x12-in. planking. Piles are to be creosoted. The total area of the platform and pier work will be 181,400 sq.ft. The completion of this work, it is expected, will provide ample space for the landing and handling of materials for the rest of the plant.

In front of the main platform, east of the pier, there will be built a launching platform for side launching. This will be 80 ft. wide by 440 ft. long and will be carried on 16-in. piles on 5x10-ft. centers, braced and reinforced by heavy piling along the edge over which the launching will take place.

POWER HOUSE—Electric power is to be furnished for operating the pumping machinery of the floating drydock, for compressing air, for machinery in the various shops and for electric lighting.

The building is to contain both boilers and power plant under one roof with fireproof dividing walls, and is to be 104 ft. wide by 148 ft. long. The building will be of modern steel-frame construction, the walls and roof to be of reinforced concrete.

There will be six 400-hp. water-tube boilers, with chain grates, such as are known to give good satisfaction with Pacific Coast coals. Provision is made for adding two extra boilers. There is also a provision for the installation of an economizer, in case it is found that the load factor warrants the expense. Draft will be obtained by a 175-ft. steel or concrete chimney.

There will be two main engines or turbines of 900 hp. each, driving 600-kw., three-phase, 550-volt generators. Condensing water will be obtained through a rock cut and shaft sunk within the power house, the circulating water being handled by a vertical centrifugal pump operated by an electric motor.

There will be a compound Corliss air compressor having a displacement of 1580 cu.ft. of free air per minute. The distribution of the air will be by means of underground piping through the yard. The entire system of light and power throughout the plant is to be controlled from the switchboard located on the main floor of the power house.

CUT AND FILL AND FOUNDATIONS—By referring to Fig. 1, it will be seen that the ground is very difficult, all the property either having to be cut down or raised to grade by fill. The location of the power house was determined by the condition of the ground, which, at this location, is of rock which will have to be reduced to the grade required. The cut and fill work is intended to go forward at the same time as the pier work, and the power plant will be commenced as soon as the site can be leveled.

The rock cut for the power house and yard grading will amount to 18,000 cu.yd., and the earth fill for grading, 73,000 cu.yd. The dredging between the pier and drydock bulkhead will amount to 100,000 cu.yd. to obtain a depth of water of 20 ft. at low tide.

BOILER, BLACKSMITH AND MACHINE SHOPS—The combined boiler and blacksmith shop is to be 76 ft. wide by 150 ft. long, with the central part 33 ft. wide. The design is of the usual steel-frame shop construction and will, in this instance, be covered with wood. The flooring will be of concrete, with heavy foundations for the large tools. The tool equipment will be very complete, comprising heavy punch and shears, rolls, plate planer, flanging clamps, etc., heavy steam hammer and a full equipment of blacksmiths' tools.

The building for the machine shop will be constructed from the same set of plans as the boiler and blacksmith shop. A very complete equipment of machine tools will be provided, comprising all machinery necessary to handle the heaviest crank and other shafting of large steamers; also boring, drilling and turning ma-

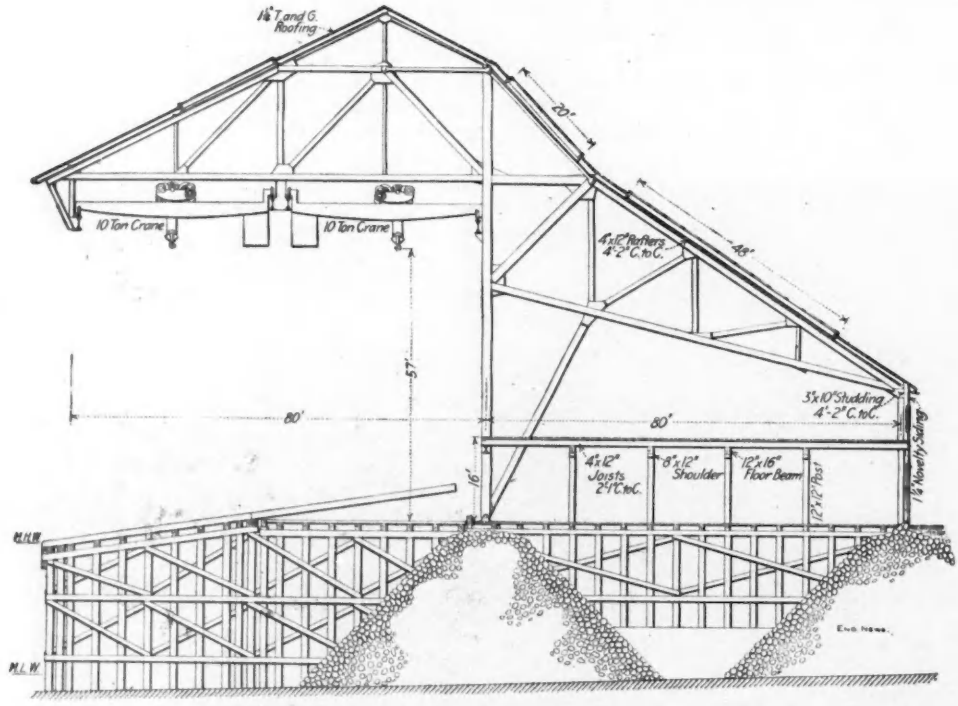

FIG. 2. SHIP-BUILDING SHED, PRINCE RUPERT TERMINAL

chinery for repairing all the secondary machine equipment of steamships. Large tools will be driven by individual motors, the smaller tools being arranged for group driving. A 15-ton overhead traveling crane will be provided for both boiler and machine shops. The building will be supplied with compressed air, and a special room will be fitted up for the repair and care of air tools.

By referring to Fig. 1 it will be seen that the location of the machine shop is such that ready access may be obtained from the drydock and water front, and it will be noticed that provision is made for entering the boiler and machine shops with railroad cars. Provision is also made for the extension of these shops as the business develops.

BUILDING SHED—On account of the excessive rainfall in Prince Rupert, it will be necessary to do the work of building the pontoons for the floating drydock under cover.

In laying out the general plan for the property and in view of its future development, the possibility of shipbuilding was carefully considered and, while there is no immediate prospect for the building of steel vessels so far from the base of material, it was thought advisable, in preparing for the building of the pontoons under cover, to make the construction of a permanent nature, suitable for shipbuilding, to be used in the immediate future for wooden shipbuilding and later on for steel shipbuilding. To accomplish this, the building shown in Fig. 2 has been developed. This building is located over the launching platform and over part of the general platform extending eastward from pier No. 1, with foundations carried down to rock. The property is laid out for side launching, this being the only practical development that was possible under existing natural conditions. The shipbuilding portion of the structure is designed to have a covered width of 86 ft. by 300 ft. long, with a clear height under cranes of 50 ft. and under girders of 56 ft. The shop section of this building is to have a width of 80 ft. and a length of 300 ft. The ground floor will be used for machinery and the upper floor will be used as a laying-out floor.

TWENTY THOUSAND-TON FLOATING DRYDOCK—The over-all length on keel blocks is to be 604 ft. 4 in. The clear width 100 ft. and the width over all 130 ft. The lifting power is the aggregate of 12 pontoons of timber construction, each 130 ft. long, corresponding to the width of the dock, 44 ft. wide in a direction corresponding to the length of the dock and 15 ft. deep. These pontoons are to be united by steel side walls or wings 38 ft. high, 15 ft. wide at the bottom and 10 ft. wide at the top, the walls being divided so that the whole structure may be used under ordinary conditions as three separate docks, one of six pontoons, with an over-all length of 269 ft., and two of three pontoons, each with an over-all length of 164 ft. The largest commercial ship upon the Pacific Coast at the present time is the "Minnesota," of approximately 18,000 tons unloaded.

The machinery for pumping the dock will consist of centrifugal pumps operated by electric motors, the capacity of the equipment being sufficient to pump the entire lifting power of the dock in less than two hours.

The structure as a whole is secured to the shore by the engagement of clamps on the dock with a vertical truss secured to the pile platform or pier in such a way that it is free to rise and fall with the tide, and when being raised or lowered with a ship. The location of these attachments is such that, when it is desired to use the dock in three separate sections, the bow section may be detached and moved around the corner of the pier work alongside the platform and secured in the same manner as provided for in its original position. To make the other two sections available as separate docks, it is only necessary to detach the middle section, comprising six pontoons, from the pier work and advance it the length of the detached section, when the sliding clamps upon the wings will coincide with those used for the previous section when the dock was operated as a whole. This will allow ample space between the center and stern sections for the overhang without interference of vessels which may be docked on them.

The pontoons are to be 130x44x15 ft. deep, with a crown of 3 in. at the center, and will have 15 trusses spaced on 3-ft. centers. There will be a center watertight bulkhead 12 in. thick, and above this bulkhead the center will be reinforced for carrying keel blocks. There will be three partial bulkheads on each side to stiffen the pontoons. All diagonal braces are heavily reinforced with anchor stocks. The arch brace is made up of planking through-bolted with screw bolts, and is intended to take the reverse stresses when the dock is floating light. This is a considerable amount when it is considered that the wings are superimposed weights carried at the extreme ends of the trusses, supported by an evenly distributed pressure over the entire bottom. Deck beams 6x12 in. are worked across the upper and lower truss members, carrying the 5-in. deck and bottom planking parallel to and reinforcing the truss members for the maximum stress.

This construction also makes it possible to get in double vertical tie rods alongside of bulkheads in such a manner that they may be replaced at any time. The whole structure is made water-tight by caulking with white-pine wedges. To protect the exterior from toredo and other marine worms, it is first thoroughly graved with tar poisoned with arsenic, then sheathed with two layers of hair felt, each thoroughly saturated with tar and arsenic, and then with creosoted lumber, also treated with arsenic and thoroughly secured with galvanized nails. This treatment, together with the facility for inspection afforded by the possibility of detaching and docking any pontoon, has been found to give satisfactory protection.

Motor Trucks Will Be Exhibited at the Chicago automobile show during the second week of the show, Feb. 5-10. A total of 44 makers will exhibit in the Coliseum and Coliseum Annex, and 30 others have taken space in the armory.

Among the special-purpose cars to be exhibited are motor fire apparatus, patrol wagons, ambulances, hearses, omnibuses, emergency wagons for street railways, dump trucks fitted with tipping bodies operated by power from the motor, trucks equipped with power winches for hoisting purposes, and a tractor truck for hauling plows in the field and driving threshing machines, circular saws and other farm machinery.

Double-Stroke Planers were described at the last meeting of the Institution of Mechanical Engineers by J. Hartley Wicksteed. One of the objects in the design of these machines was the elimination of the defect inherent in the planing machine, viz., its idle return stroke. Previously attempts have been made to adapt the planer to double-stroke cutting, but the objection has always held that with an equal speed of the planing-machine table on both the forward and backward cut, when the work does not permit of the use of both tools for want of clearance at the end of the stroke, the absence of a quick return motion on the idle stroke discounted the advantages gained on other work where double cutting could be employed.

This objection is removed in the double-cutting Buckton planer by adopting for the drive a variable-speed Vickers motor, using a small auxiliary motor for the subsidiary operations such as feeding and traversing the tool boxes. The manner of double cutting is to fix both tools back to back and thus cut, on a single cycle of the table, two furrows of equal width and depth. Other advantages claimed for the arrangement are that back to back tools save each other from wear, also that the first roughing cut is more uniform when made with two tools.

Another design retains the continuous drive, either by motor or from countershaft, and the idle stroke. The belts, however, do not shift on fast and loose pulleys, but are themselves tightened and loosened alternately by rocking jockey pulleys, and run loosely in loops at the half stroke under their respective pulleys without touching them. Belt wear is thus considerably reduced.

The quick-return belt is greatly relieved also by the employment of a spring which, compressed at the end of the cutting stroke, is free to liberate the energy so stored, and assist the table to start on its quick return. These improvements should materially assist in reducing the inferiority of the planer to continuous cutting tools from the point of view of economic removal of material. —Engineering Review, London, Dec. 15, 1911.

A Novel Gas-Holder Foundation

By Hunley Abbott*

A description of the use of the bulged-bottom "Pedestal" concrete piles in the foundation of the large gas-holder for the New Haven Gaslight Co., New Haven, Conn.

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Foundations for a large gas-holder at New Haven, Conn., have recently been installed using concrete piles with reinforced-concrete capping, a construction which has proved not only exceedingly strong, but also decidedly economic as compared with the ordinary types of construction used under similar conditions.

The new gas-holder of the New Haven Gas Light Co. will provide a storage capacity of 3,088,000 cu.ft. at 7½ oz. gas pressure, and the guide frame will have a height above the foundations of 206 ft. The diameter of the smallest of the five sections of the holder will be 149 ft. 10 in., each section being 34 ft. deep. The water tank is 163 ft. in diameter, 35 ft. 3 in. deep, with bottom plates ⅛ in. thick, excepting a ½-in. outer course, and side plates in six courses grading from 1⅛ in. thickness at the bottom to ⅜ in. for the upper course. The tank will hold practically 5,000,000 gal. of water. The weight of the water alone is thus over 20,000 tons. The foundation had to be designed to carry the filled tank plus the weight of the holder and guide frame, which made an aggregate load of about 30,000 tons.

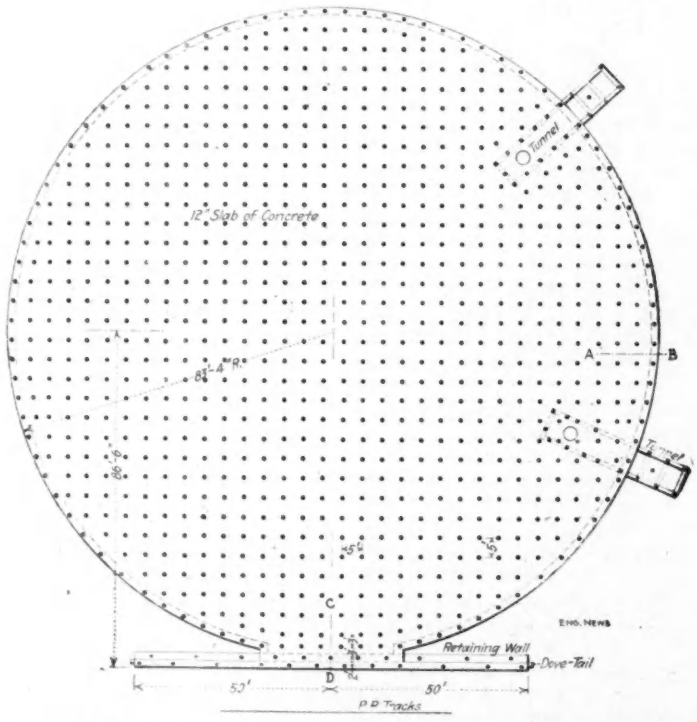

FIG. 1. FOUNDATION PLAN OF GAS HOLDER, NEW HAVEN, CONN.

The site of the new gas-holder was many years ago a sandy beach over which a layer of mud, varying from nothing to 12 ft. thick, had been deposited and over this mud a fill had been made of 4 or 5 ft. of loose earth. This fill had been in place for a number of years. East St. is on the west side of the lot and on the east side run the tracks of the N. Y., N. H. & H. R.R. The original surface of the ground slopes off from the street down to the railway tracks with a drop of about 10 ft. The site of the holder was first brought to a level grade, the cut on the up side being used as fill on the low side, and the surface thoroughly compacted by a steam roller. Over the whole area of the holder foundation "Pedestal" concrete piles were driven on 5-ft. centers in each direction. There were 966 piles driven and they carry a load of 31¼ tons each.

The piles were of various lengths and driven down in the subsoil a sufficient distance to insure the enlarged foot being thoroughly embedded in the sand. The method of driving and forming these piles is described in ENGINEERING NEWS, Dec. 16, 1909, p. 684, and will be of interest in this connection.

The piles were all cut off at a given elevation and two ¾-in. square twisted rods were run over the tops of each line of piles, in both directions. Over these rods were spread two layers of 2x12-in. mesh, ¼-in. diameter Clinton wire cloth, run in opposite directions, making two complete sheets of mesh metal over the whole foundation area. These rods and the cloth formed the reinforcing for a concrete-slab disk 12 in. thick and 166 ft. 8in. in diameter, completely covering the tops of the piles. At the outer edge of this disk is a concrete girder 18 in. wide and 3 ft. deep, reinforced with two ¾-in. square twisted rods. This girder stiffens the slab on its edge where the steel tank superstructure rests, and also goes into the earth deep enough to prevent any lifting action from frost. All concrete for piles, slab and girder, was a 1: 2: 4 mixture. The general layout of the piles may be seen in Fig. 1, and the details of the slab and girder construction are shown in Fig. 2.

On the side of the holder next to the tracks the elevation of the foundation is about 4 ft. above base of rail and, therefore, a concrete retaining wall, 100 ft. long, was constructed, tangent to the foundation disk and parallel to the tracks. A section through this wall at the point of tangency is shown in Fig. 2. The wall is 4 ft. thick at the base and 2 ft. at the top and 8 ft. 6 in. high.

The pressure on this wall is, under ordinary circumstances, only that due to the action of the earth which it retains, but, owing to the possibility of shock from derailments or other accidents along the adjacent railroad, steel reinforcing rods were placed as shown.

On the north side of the foundation are two tunnels to carry the 30-in. inlet and outlet gas pipes. These tunnels are 37 ft. 9 in. long and project under the holder foundation 24 ft. 4 in. The inside cross-section is 6x6 ft.; the bottom and sides are of concrete 12 in. thick, and the reinforced-concrete foundation slab forms the roof of the tunnel. The roof is further strengthened by 15 in. I-beams at 4 ft. intervals along its length. At the outer end of the floor of the tunnel is a 4x6-ft. pit 2 ft. 9 in. deep, in which the cut-off valve sits.

The top surface of the foundation slab on which the tank rests was made level with a variation of not more than ½ in. over its whole area and an annular band around the outer circumference of the disk about 10 ft. in width was made level to not more than ¼ in. variation. The top of the disk or slab was then covered with a mixture of dry cement and sand mixed in equal parts, and the steel tank

lowered upon this 1½-in. thick layer. The cushion of dry cement insures a uniform distribution of the load of the tank to the surface of the slab. In time the cement will harden by the moisture in the air and will form a permanent part of the foundation, taking up any irregularities in the tank, and thus insuring an even distribution of the load over the whole foundation.

In the foundation design as first planned, excavation was to have been made down below ground water level, wooden piles were to have been driven and capped with concrete, and the tank placed on the concrete cap. Surrounding the tank was to be a retaining wall. Aside from the cost of this type of foundation, which would have been considerably more than the concrete-pile design, one of the most serious drawbacks is the fact that the bottom of the gas-holder tank would have been considerably below ground level, and therefore subjected to the corrosive action of drainage water.

In the type of foundation actually built it is possible to place the whole tank above ground level by the use of concrete piles and, furthermore, by reason of the special type of pile used, a foundation strength of large capacity was obtained at a comparatively small cost.

The cost of the concrete piling was about 59c. per ton of load carried, and the cost of the reinforced slab about 44c. per square foot.

While discussing the construction and cost of gas-holder foundations, it may be of interest to mention the details of some other holder foundations, under similar soil conditions. The "Handbook of American Gas Engineering Practice," by Latta, says:

> The Stacy Manufacturing Co. cite a recent instance of a holder of about one and one-half million cu.ft. capacity erected upon soft ground at a cost for (wooden) piling of 75c. per sq.ft. over the whole area of the same. These piles were capped with 2 ft. of concrete, but the foundation failed immediately upon the filling of the holder tank with water.

In "A Holder Foundation on Quicksand," by C. A. Learned, in *American Gas Light Journal*, Feb. 24, 1902, there was a description of the foundation of a holder 115 ft. in diameter, 103 ft. high, holding 700,000 cu.ft. of gas. The total weight was 9100 tons. The soil conditions were as follows: Five feet of loam on top, then a thin layer of cemented gravel, and quicksand below that to a considerable depth. The foundation site was excavated down to the layer of gravel and a concrete wall 5 ft. high constructed around the circumference of the holder. Inside this circular wall was placed compacted gravel and sand, and the whole capped with a 12-in. slab of concrete. The estimated cost of this foundation is about 90c. per ton of load carried, but from the unit costs given by Mr. Learned, it is quite probable that this foundation would cost at least $1.10 per ton of load carried, today. No piles were used in this construction.

ENGINEERING NEWS, of Oct. 26, 1905, gives a description of a typical modern gas-holder. The tank was 195 ft. in diameter and 39 ft. 3 in. high, holding 8,712,200 gal. of water. The total load on the foundation was something under 60,000 tons.

> To construct the foundation 4100 (wooden) piles were driven and capped, first with 12x12-in. timbers and then by 6x12-in. planks laid tight. On this capping was laid a circular brick wall 5 ft. 6 in. thick and 8 in. deep, and having an outside diameter of 199 ft. The space within this wall was filled to within 18 in. of the top with gravel, washed and rolled. The remaining 18 in. was filled with concrete on which the steel bottom of 5/16-in. plates was constructed.

The estimated cost of this foundation is about $1.50 per sq.ft., or about 80c. per ton of load carried.

Returning to the New Haven gas-holder, some interesting features of the superstructure will be given.

A novel use will be made of the tank water as a cooling medium for the hot circulating water from near-by condensers,

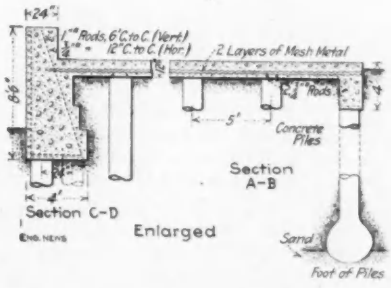

FIG. 2. DETAIL SECTIONS OF GAS-HOLDER FOUNDATION, SHOWING PILE FOOTINGS

and the warm circulating water will assist in the winter to prevent freezing.

The holder sides of all five lifts are composed of 12 courses, the 8 intermediate courses between the two upper and two lower rows being of No. 10 B.w.g steel. The double-riveted spherical crown of the inner lift comprises 633 plates in 13 courses concentrically arranged around a 72-in. diameter center plate, ½ in. thick. The nine intermediate courses adjoining the first course from the center plate are of No. 9 B.w.g. steel.

Each lift is provided with 20 top carriages equipped with adjustable radial and tangential rollers and 40 bottom rollers, which maintain the vertical alignment of the holder sections during the operation of telescoping. The 20 plate-girder standards of the guide frame, which resist the wind loads and strains transmitted by the carriage rollers, are connected by six tiers of latticed box girders and reinforced by diagonal bracing and tie-rods. Each standard, which is 171 ft. in height, built up in three sections, tapers from 40 in. in width at the base to 26 in. at the top.

To insure thoroughly gas-tight connections throughout, the light as well as the heavy plates were calked during the erection stage, so that very few, if any, leaks will have to be when the holder is tested. The calking of the light sheets while assembling insures metal-to-metal joints, and is the most recent practice in gas-holder construction, superseding the use of oxidizing agents or of inserted fillers at the seams.

The method of hoisting the guide-frame members in position was on the floating derrick principle, utilizing the buoyancy of the holder sections when partially inflated with air to regulate the working height of the erection equipment. A rotating trammel derrick, pivoted on the central crown-plate, with the opposite end of its radius arm carried on a circular track on the outer course of the crown, and an adjustable boom overhanging the side of the holder, was used to raise the materials into position. The lower section of the guide frame, which is 60 ft. in height above the tank walk-around, was erected complete while the holder was down, and will maintain the vertical alignment of the lifts when inflated to the proper working height for raising the middle-section parts into position. An eccentric load of about eight tons will be sustained in this manner when the middle-section standards, weighing four tons each, are being erected.

The gas-holder was furnished, erected and designed by the Cruse, Kemper Co., of Ambler, Penn., while the MacArthur Concrete Pile and Foundation Co., of 11 Pine St., New York City, was the contractor for all the sub-structure work. Mr. Robt. E. Wyant, of the New Haven Gas Light Co., was engineer of this work.

Government Insurance in Germany against the casualties of accident, sickness and old age is described in a pamphlet just published by the Workmen's Compensation Service and Information Bureau, 1 Liberty St., New York City. The pamphlet is a reprint of a paper by Dr. Ferdinand Friedensburg, who was for 20 years president of the senate of the German Imperial Insurance department. While expressing his appreciation of the benefits derived from the German insurance system, Dr. Friedensburg describes, as the result of his long experience, many abuses which have crept into the system and which deserve serious consideration by other countries in framing laws for workmen's insurance.

A Japanese Bridge Project contemplates the construction of a great bridge over the Shimonoseki Straits for railway and highway purposes, to replace ferry connection. The bridge would be at an elevation of about 165 ft. above water, and its total length would be over 3700 ft.

Reinforced Concrete Stresses

By Ernest McCullough *

Permissible unit stresses in reinforced concrete have been increasing consistently through the past ten years. Furthermore there are many designers who use stresses in excess of those generally permitted. This article is an inquiry into the desirability of the practice.

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The majority of engineers today who specialize in reinforced concrete are in the employ of companies selling reinforcement, or are in the employ of large contracting companies. These engineers, who are responsible for the design and erection of most of the structures going up in reinforced concrete, are using much higher stresses than were common five years ago, and, when not restricted, are using higher stresses than any building ordinance stipulates, although building ordinances adopted within the past two years permit higher stresses than even the commercial engineers advocated only a few years ago. On the other hand, their professional competitors, the men in private practice, as a rule, govern their work by the recommendations of the Joint Committee, the works of eminent professors who have investigated the material, or are compelled to observe various building regulations and in any event are hopelessly outclassed in competitive work.

Either competition is becoming so keen that the commercial engineers (the word commercial being here used simply for differentiation and not in the sense of a reproach) are willing to risk everything for gain, or the conservative wing, of which the writer has always been a member, has little reason for the strong conservative spirit displayed. It is high time this matter of stresses be effectually threshed out. The writer has talked with a number of men who were on commissions charged with the revision of building ordinances, and found that such of them as are engaged in reinforced concrete design are using higher stresses in out-of-town work than one would imagine they would from the fact that they helped in the preparation of conservative ordinances. When interviewed, they claim that the reinforced concrete provisions were a compromise and that certain members, structural engineers specializing in steel design, went to councilmen and succeeded in so altering some provisions that reinforced concrete was not given fair competition with structural steel. Upon interviewing the aforesaid steel designers, they frankly admitted the truth of the charges and did not speak very nicely of the "reinforced concrete cranks, who do not care how many people are killed provided they can turn over a dollar."

In defending this unauthorized use of high stresses, the arguments of the commercial engineers may be reduced to three: (1) high stresses in concrete design have never caused a failure; (2) concrete increases in strength with age, which permits low factors of safety on the usual basis of short-time strength, and (3) the published laboratory tests upon which most specifications and laws are based are old ones, which have since been superseded by private and unpublished actual building tests showing much greater strength in the concrete. These three arguments will be taken up here separately.

Failures of Reinforced-concrete Structures

In an article in Engineering News, Oct. 26, 1911, p. 498, outlining the principal causes for failures in reinforced-concrete structures, the writer stated that he had not discovered the use of high stresses to be the cause of any failures except when accompanied by inferior structural design, but this statement he wishes now to modify slightly. The greater number of failures are caused by careless load assumptions, laziness on the part of the designer and crass dishonesty in the designing office. Inferior workmanship, the *bête-noir* of the conservative man, is much more easily guarded against than poor designing. Failures, as generally understood, occur before the building is occupied, and high stresses alone do not cause such failures, the only kind the public hears of. The failures of a nature that cause discontent two or more years after the building is occupied, and create a reasonable doubt as to the safety of the building, are undoubtedly caused by the use of high stresses in designing.

The writer has been called upon by several owners to study failures and the causes, but is estopped from making public the facts in connection with particular structures. Owners do not wish any facts to become public which are in any way a reflection on the strength of the building they own, especially when they are so difficult of repair as are reinforced-concrete structures. He can say, however, that the majority of cases of discontent come from the fact that cracks are appearing and floors are settling, although the designs when checked conform to all theoretical requirements and show the structure to have ample strength. The writer is also compelled to admit that in every case so far brought to his notice, the reinforcement has been without mechanical bond. Evidently there is something happening which might be termed "fatigue." To the subject of fatigue in metals, the late J. B. Johnson devoted an entire chapter in his work on "The Materials of Construction," and in the first paragraph called attention to the fact that this phenomenon was not due to a general deterioration of the material, but that some of the incipient defects gradually extend their influence in an irregular plane of rupture. Prof. Johnson said, "the gradual fracture of metals would be a more truly descriptive term to use."

Concrete is not a homogeneous material, and the habit of depositing concrete instead of mortar around reinforcement does not ensure always the best possible contact with resulting perfect adhesion. Concrete tends to shrink in setting and at first grips the reinforcement securely. The shrinkage continues and the concrete tends to shrink toward the center of gravity of the mass, thus causing incipient cracks in the plane of the reinforcement. The gradual fracture of the material results and as a consequence floor panels from 15 ft. to 20 ft. span have suddenly settled as much as ½ in. three years after the construction of the building. Owing to the nature of the business carried on in the structures examined by the writer, the temperature on the underside of the slab was never less than 70° F., and at times must be very much higher. Half an inch of concrete under the steel is easily affected by the dehydration process constantly proceeding, and something slips. The writer never favored smooth rods and bars, and never designed a structure using them. He regarded the mechanical bond as cheap insurance, for there is now on the market admirable steel having good mechanical bond, on which there are no patents. It has been found that bending the ends of reinforcing bars is very efficient anchorage, while stirrups are necessary when the diagonal tension is excessive. A slip of 0.01 in. will cause an appreciable settlement in a floor and this amount will not be prevented by loose stirrups, so it should be stated as an axiom that stirrups must be rigidly attached to the horizontal reinforcement. The writer favors very much reinforcement that is gradually decreased toward the supports, the turned-up ends going over the supports for anchorage and to care for negative stresses. Furthermore all stirrups

should be placed after proper computation and not in a regular manner, nor in a haphazard manner.

The straight-line formula is approved by the best authorities, but with this qualification, that safe working stresses be employed. Turneaure & Maurer say (p. 211, 2d ed.): "It is, however, desirable that the working stresses be selected with some reference to ultimate strength, although with principal reference to elastic strength." The usual practice is to design with reference to the ultimate strength of the concrete and the elastic limit of the steel, neglecting the strength of the concrete in diagonal tension. When the proper strength in diagonal tension is exceeded, stirrups are supplied. The writer believes that this matter of diagonal tension is a most important one, and no design should be accepted which permits a safe stress to be exceeded. Furthermore, to make matters perfectly safe, stirrups should be provided to take care of all diagonal tension. This may make larger sections than we have been accustomed to, but durable structures will result.

Increase in Strength with Age

Owing to the great amount of advertising the cement companies and steel companies have been doing, the man on the street knows that concrete increases in strength with age. We know that the increase is 50% in six months, and there is a further increase of practically 50% in five years. The average owner concludes, therefore, that his floors may be loaded more heavily in a year or two than in the first few months. The writer has found this opinion to be the prevailing one when called upon to advise with owners, and no doubt a number of minor failures are due to this fact. An example worked out will show how this operates:

Using the straight-line formula with the stress recommendations of the Joint Committee, a slab or beam has been designed with

$f_s = 16{,}000$ lb. per sq.in.,
$f_c = 650$ lb. per sq.in.,
ratio of deformation $= 15$.

The forces are balanced and the moment factor is practically 107. At the end of some interval the concrete has increased 50% in strength and the ratio of deformation is lowered to 10. Retaining the same moment of resistance, we find that the concrete stress is 750 lb. per sq.in., and the steel stress is reduced to practically 15,600 lb. per sq.in. There has been a considerable increase in the possible strength of the concrete, but less than 3% in the steel.

Coincident with the increase in the modulus of elasticity and the reduction of the ratio of deformation, it has been assumed that the concrete has increased 50% in strength, so a new resisting moment can be obtained. Keeping the steel stress down to 16,000 lb. per sq.in., the new moment factor is practically 110, and the concrete stress is 770 lb. per sq.in. This is still too low, for the possibilities that lie in the concrete for a safe fiber stress of 1000 lb. per sq.in., should be possible. Using this stress with a ratio of deformation $= 10$, the new resisting moment is practically 143, and the required steel stress to balance should be practically 21,000 lb. per sq.in. If this increase in strength had been taken into consideration at first, the steel ratio would have been 0.01 instead of 0.00766; or, the steel ratio at first adopted could have been retained and a concrete stress used of 770 lb. per sq.in.

The common concrete stress in use today by commercial engineers is 800 lb. per sq.in., and some designers even use 1000 lb. per sq.in., when their company has the contract, and they believe extraordinary pains will be taken to insure graded concrete, with good workmanship throughout. The concrete designer claims the conservative men use a high factor of safety for concrete, a material that increases in strength with age, while using lower factors of safety and higher resulting stresses with all other materials, which begin to deteriorate from the moment they are placed in structures. The commercial designer, however, is very inconsistent in using a high fiber stress in steel combined with a high fiber stress in concrete, *for the steel will forever, or at least as long as the structure stands, determine the resisting moment. Of what service, then, is the increase in the strength of the concrete?*

The writer, in common with the majority of engineers in private practice, must depend upon published results of tests and such tests as it has been his fortune to conduct. These have been upon small units and shared the lot of all published tests in that they were ragged. One or two would give such high values as to lead him to think certain theories could be overthrown, only to be contradicted by the tests following, which might be so far below normal as to cause a return to the extremely conservative band of workers. The commercial engineer argues thus: Grant that concrete at the end of one year is 50% stronger than at the end of one month and at the end of six months is practically 30% stronger than at the end of one month. The compressive strength at the end of one month being 2000 lb. per sq.in., it will be 2600 lb. in six months, and 2400 lb. in three months. Few buildings will be occupied within three months after the concrete is poured, so the commercial engineer feels justified in using one-third the three months' strength, or 800 pounds.

The fiber stress mentioned is always the edge stress and the average stress is, of course, one-half of this. Some commercial engineers argue that since the strength of 2000-lb. concrete will be practically 2600 lb. at the end of six months and 3000 lb. at the end of one year, there is no valid objection to the use of one-half the six-months strength in designing. This will give 1300 lb. per sq.in., practically 43% of the one-year strength, with the factor of safety constantly increasing. To this point the writer is not yet prepared to follow. Arguments such as this will, however, continue to be advanced so long as conservative men and building ordinances compel concrete designers to be governed by the lowest strength in their material, while designers in other materials are governed by these materials at their best, with a factor of safety constantly lowering. There is food here for thought.

The grievance of the conservative engineers lies in the fact that owners are not given proper information about these matters. A conservative engineer in private practice prepares plans for the owner in which future increase in strength of the concrete is taken into account, and the steel proportioned accordingly. When bids are asked, the owner is besieged by engineers, or men with engineering training, who offer him free plans calling for a smaller amount of steel. That the actual steel stress decreases with an increase in strength of the concrete is shown, but the owner is not told how pitifully small an effect this has on the structure. He believes that he obtains the full benefit of the hardening and strengthening of the concrete. The whole attempt is to sell steel, and a showing of how a slight increase in steel will make a difference in the concrete in favor of the owner, is not shown. At the present time in the United States the commercial engineers who sell reinforcing material are having too much to say in the preparation of building ordinances and in the design and erection of buildings. Many of them say in personal conversation that they hate to do it, but their positions depend upon the amount of material they can sell. The most inconsistent thing today in connection with the design of reinforced concrete is the use of extremely high stresses in steel and concrete with a conservative value for the ratio of deformation. Prof. Talbot pointed out several years ago that the only benefit of a high elastic limit in the steel is the larger factor of safety obtained.

The high steel stress properly goes with the low concrete stress, and vice-versa. A few examples worked out on the lines of the one above given will show this. The natural conclusion is that the straight-line formula should be consigned to limbo and the parabolic formulas resurrected and put in service. This will mean more steel, which should cause steel manufacturers to rejoice, were it not for the competition now existing which compels each company to demonstrate to the owner how much steel he can save by using a certain kind. The

high steel stress has come in as a purely commercial proposition with no pretense of benefiting anyone except the man selling steel. Certainly owners are hurt by it.

Published and Private Tests

It has been said that engineers in private practice must depend upon information given by experimenters, these experimenters usually being professors in schools having well equipped testing laboratories. A number of these professors have written books and contributed to discussions before technical societies. The commercial engineers refer slightingly to the fact that the man in private practice must rely upon the work of professors, most of whom left the experimenting to students. The owner is shown that the last tests made were made in 1907, or thereabouts, whereas the company represented by the aforesaid engineer has tests made within the past three months. The tests the private practitioner must rely upon were small units, whereas the tests pointed to with pride by the commercial engineer are upon complete structures. The writer pointed out to several owners that the college tests were to destruction and the process was studied step by step, whereas the tests on completed structures are with loads of a limited amount, and no one knows what the real strength is, or whether the structure is hurt by the test.

These same commercial engineers, while discounting the tests made in colleges, on the ground that they were not made by the professors, but by immature students, oftentimes volunteering the statement that while at college they assisted in these tests and therefore know their inadequacy, employ the eminent professors to conduct the tests on completed structures. They thus magnify the professor, because of his reputation as a concrete man and impress the owners with the fairness of the test, while excusing the conclusions the professor has given to the world over his own name, by saying the professor would not give such conclusions to the public if he had time now to write another book.

A commercial engineer told the writer that in a number of cases it has been found that the fiber stress in the steel was from 20% to 30% lower than the calculated stresses. In one particular instance it was found that a steel stress of only 5000 lb. per sq.in. was found on a short span, when the computed stress should have been 16,000 lb., because of the arching action developed. On a longer span the steel stress was found to be only 12,000 lb., when it should have been 16,000 lb. By means of delicate instruments which will measure 0.001 in., clamped to boards in a room not particularly protected from atmospheric influences, evidence of negative concrete stresses, indicative of arching action, have been found, so that all theories heretofore held regarding reinforced-concrete designing must sooner or later be upset.

These mysterious tests, about which so much secrecy is maintained, for fear of competitors profiting, but which are mentioned with bated breath to prospective customers of steel, are doing a great deal of harm. Frankly, the writer believes most of them to be positive untruths. When the designer forgets a large part of his load his structure will fail as surely as the sun will rise, no matter how low the stresses used in the design, for to forget part of the load is to increase the fiber stresses in the materials. Why should beams tested in laboratories fail so uniformly under certain loads as to confirm the eminent professors' findings and yet when these same eminent professors test beams, girders and slabs in combination in structures so much more favorable results are obtained? These professors know how their names are being used, and they owe a duty to their profession, if engineering is a profession, to make no more tests for proprietary systems unless they have permission to make the results public.

The pay of these commercial engineers is not large, so it seems strange that they work so hard to discredit engineers in private practice, when these same engineers in private practice are the men to whom they apply for a position when their employers let them go. Within the past month the writer has received applications from a number of commercial engineers who are soon to be let out on account of dull times, and the experience records these men furnish are excellent. If a physician or a lawyer or a commercial traveler could show an equally creditable record his fortune would be assured. It is very disconcerting to find out how cheaply these most excellent men may be hired. A few get good pay, as pay for engineers goes, but the majority receive such poor pay that it is a never ceasing wonder to the writer why they work so hard to discredit men in private practice, when they know their own positions are insecure and opportunities for advancement are so limited. When the best years of their life are gone and dull times cause them to be laid off, it is to private practice they must turn in nine cases out of ten, and a few confess that much they told owners was not justified by the facts, and the more honest ones become extremely conservative. When professors, however, write books which create conservative designers and then knowingly permit commercial engineers and promoters of engineering materials to make wrong use of their names in conversation with prospective customers, what can we expect in an ethical way from the graduates?

The writer hopes that if the commercial engineers have been unjustly handled in this article, they will come out in a public discussion of the subject of stresses in steel and concrete and back up the *sub rosa* tales they tell customers.

The Manufacture of Paint and Varnishes in the United States is reported for the years 1904 and 1909 by a recent press bulletin of the U. S. Census Bureau. The general figures for the industry are shown by the accompanying table. It should be noticed that these figures do not include kaolin and ground earths, or the blacks made by establishments reporting bone, carbon and lampblack as their chief products. The figures do not include the lead and zinc oxides made by lead and zinc smelters as byproducts. In most cases the various items shown are self-explanatory. The item "Value Added by Manufacture" represents the difference between the cost of materials used and the value of products after the manufacturing processes have been completed.

GENERAL SUMMARY

	1909	Per cent. of increase, 1904 to 1909
Number of establishments	791	24
Capital	$103,995,000	38
Cost of materials used	$79,016,000	32
Salaries	$10,378,000	83
Wages	$8,271,000	32
Miscellaneous expenses	$13,538,000	40
Value of products	$124,889,000	37
Value added by manufacture	$45,873,000	48
Number of salaried officials and clerks	7,200	63
Average number of wage earners employed during the year	14,240	22
Primary horsepower	56,162	36
PRINCIPAL PRODUCTS.		
Pigments, pounds	502,465,692	64
White lead, dry	85,234,414	37
Oxides of lead	68,344,813	37
Lampblack and other blacks	1,810,445	139
Iron oxides and other earth colors	111,674,675	131
Other dry colors	157,469,598	60
Barytes	49,496,025	122
Pulp colors, sold moist	28,435,722	12
Paints in oil:		
White lead in oil, pounds	246,567,570	14
Paste, pounds	162,356,330	23
Already mixed for use, gallons	33,273,461	49
Varnishes, gallons:		
Oleoresinous	18,476,523	28
Damar and similar turpentine and benzine	3,481,231	
Spirit, not turpentine	1,181,746	—24[2]
Pyroxylin	1,880,141	1,168
Fillers:		
Liquid, gallons	1,159,569	10
Paste, pounds	14,050,329	243
Dry	157,966,172	
Putty	63,502,048	
Water paints and kalsomine:		
Dry or in paste, pounds	47,465,265	70
Already mixed for use, gallons	522,283	323

[1]In addition, in 1909, 144,472,173 lb. of pigments, 2,682,023 lb. of paste in oil, 1,006,956 gal. of paints already mixed for use, 344,033 gal. of varnishes and 4,379,894 lb. of paste fillers and putty; and in 1904, 66,353,181 lb. of pigment, 2,101,536 lb. of paste in oil, 375,998 gal. of paint already mixed for use, 465,241 gal. of varnishes and 668,376 lb. of paste fillers and putty were made by establishments engaged primarily in the manufacture of other products.

[2]Minus sign denotes decrease.

Repairing Asphalt Paving in Chicago*

In 1907 the legislature of Illinois authorized the collection of a wheel tax in Chicago with the proviso that the money so raised should be expended solely in the maintenance of streets. The amount raised under the wheel tax annually is about $600,000, and if properly expended should improve the condition and extend the life of pavement. The first contract let for this purpose, however, resulted in the wasteful conditions disclosed by the report of the commission on city expenditures.

The accompanying report gives the results of further investigation by the Chicago Bureau of Public Efficiency of the contract for asphalt street-repair work for the city for the year 1911, and the methods of the contractor in prosecuting the work. The investigation was made by A. J. Hammond, chief engineer of the Chicago Bureau of Public Efficiency, and H. J. McDargh, assistant engineer.

EXCESSIVE REPAIRS—Specific instances were noted by bureau investigators in which the cutting out of the asphalt pavement extended from 6 in. to 2 ft. beyond the lines laid down by the inspector of the city. Another instance was a series of repairs extending about 3 ft. from the curb, with stretches of good pavement between the patches, in which the contractor removed the good pavement, even though it was not marked, and for no obvious reason.

The contractor is given permission to use old asphalt paving mixtures in combination with the binder stone, if crushed and augmented with 1% of asphaltic cement. In removing defective pavement, the cost of removing an additional 6 in. or 2 ft. of adjoining good pavement is negligible. This good pavement is hauled to the asphalt plant, worked over, then used as binder in making repairs, and paid for by the city at the rate of $5 per ton. A great part of the material for binder is thus obtained by the contractor at an exceedingly small cost.

FAULTY METHOD OF REMOVING OLD PAVEMENT—In removing defective pavement it is the custom to lift it up with a pick or bar and break it off with the cutter. When the edge of repair is reached this method causes the pavement to be lifted beyond the line marked by the inspector and destroys the bond between the binder and concrete base. Inspection showed instances where this extended 18 in. beyond the inspector's lines. If the pavement was brittle, cracks developed and unless more pavement was cut out to remove the cracks, moisture would find its way to the concrete base and cause the binder to deteriorate, thus shortening the life of the wearing surface.

The loss to the city from the use of such methods is manifest in two ways: (1) in the cost of additional area of pavement repaired; (2) in the cost of future repairs necessitated by failure of pavement due to such methods. The attention of two street inspectors was called to this faulty method of removing the old pavement, but no remedial steps were taken until the chief inspector was informed. Orders were then issued to cut through the top and binder along the inspector's line before lifting the old pavement, and this is now being done, as far as can be observed.

BINDER LAID COLD—The specifications require that the binder be brought upon the street at a temperature ranging from 200 to 325° F. Numerous instances were noted where this binder could be handled with bare hands. A load of binder arrived on the work, on June 13, too cold to shovel from the wagon. An effort was then made to dump it, and this was successful after a period of 6½ min. by using a rake and shovel in pulling it out from below. A large portion of this load was in lumps, and when the binder was distributed the lumps were broken up with rakes and shovels and used as if in the best of condition.

A load of binder was unloaded and distributed during a rainstorm, the foreman and inspector standing under an umbrella while the work was being done. When the binder was tamped, water came to the top through the material.

When removing the old pavement the refuse is frequently piled up along the gutter, or either side of the opening, in such manner as to prevent rolling of the binder, as required by the specifications. If the binder is not compressed evenly it results in areas of varying density, and as the top is spread over it evenly and then rolled, there will be places in the repair that are less dense. This will cause depressions in the pavement after a time.

BINDER NOT COVERED PROMPTLY WITH WEARING SURFACE—Unless the binder is covered with the wearing surface within a reasonable period after it is laid, it becomes soiled from traffic and a thin layer of foreign matter forms between the binder and top. The traffic also breaks down the edges of the old pavement, necessitating additional cutting and making a larger area to be paid for.

INSUFFICIENT MIXING, TURNING, RAKING AND ROLLING OF SURFACE MIXTURE—The specifications require that the wearing surface "shall be dumped at such distance from the work that all of the mixture must be turned and distributed to the place where it is to be raked."

Inspection showed that the wearing surface was shoveled from the wagon to a point as near as possible to where it will be used. The excess amount is raked forward. That portion which strikes the binder first, through its 6-ft. fall, is more or less compressed by the weight above it and is given a greater density than that raked forward. When the roller is brought into use it does not compress as much as does the raked material, and an uneven surface is formed.

This lack of sufficient mixing, turning and raking is indicated by the uneven and honeycombed condition of the surface after its preliminary rolling. It has been a common occurrence to see the men with smoothing irons working on these small holes in an effort to close them up before the final rolling. If they do not succeed, the traffic will close them, but an uneven surface results. Should the openings remain undisturbed for any length of time, they afford a path for water to reach the binder and cause decomposition of the pavement.

The specifications require that the "initial compression must be effected by means of a small roller," etc. "The final compression shall be effected by a 10-ton roller, or the equivalent of not less than 250 lb. per running inch width." At no time has there been any but the large roller on the work, and should it be placed in use when the material is too hot it causes the mixture to roll, which is difficult to overcome, unless the repair is large enough to allow of diagonal and cross rolling by an experienced mechanic. Should the surface mixture be allowed to become too cool before rolling, the material, when compressed, does not bond properly and a weak pavement results. It is therefore very important that both rollers should be used.

LACK OF STONE IN BINDER—The specifications permit the contractor to crush old asphalt surface-paving mixtures and use this material in combination with the binder stone in making binder.

The first inspection disclosed that the old material was being used, but that no stone was in the binder. It was nothing unusual to find pieces of the old pavement in this binder, showing the careless manner in which it had been prepared. Shortly after regular inspection had been begun by the bureau, stone was added to the binder, and (so far as seen) it has been continued up to the present time.

MUNICIPAL ASPHALT PAVING REPAIR PLANT—In view of the difficulty experienced in securing full value for the wheel-tax fund expended in street repairs, the bureau suggests that the city consider seriously whether the work of asphalt-paving repairs might not be more economically performed by the city itself.

*From a report issued in October by the Chicago Burau of Public Efficiency (see "Engineering News," Sept. 7, 1911); Herbert R. Sands, Director, 900 Masonic Temple, Chicago.

Purchase of the Allegheny River Bridges at Pittsburg, which was decided upon last summer, will shortly be completed by the determination of awards for the Seventh St. and Ninth St. bridges. An issue of bonds for $1,550,000 by the county to pay for the Sixth St. bridge is about to be made.

Steel Sheet Pile Retaining Walls

By Myron H. Lewis*

A type of steel sheet piling retaining walls is here described, together with a comparison of the cost of this type with that of the ordinary L-shaped reinforced-concrete retaining wall.

*Consulting engineer, 11 Broadway, New York.

About one year ago the writer was called in by Messrs. Leaw Bros., concrete contractors at Asbury Park, N. J., to report to them on the strength and stability of the sea wall at Allenhurst, N. J., on which work they were then engaged.

According to Fig. 1, which is a copy of the sketch submitted to the writer at the time, it will be seen that the base of the wall was much narrower than is usually specified for a wall of the height shown in the diagram. It will be also noticed that this wall was to retain a wedge-shaped mass of wet sand filling, between an old wooden bulkhead and the rear face of the wall. The top of the wedge was 5 ft. wide, sloping down to zero at the bottom. No weep holes were provided to drain the backing, and consequently it was necessary to assume hydrostatic head in computing the stability, as the sand was liable to be wet at times; in fact, at one time the bursting of a water main was sufficient to cause a portion of the wall to move forward more than a foot.

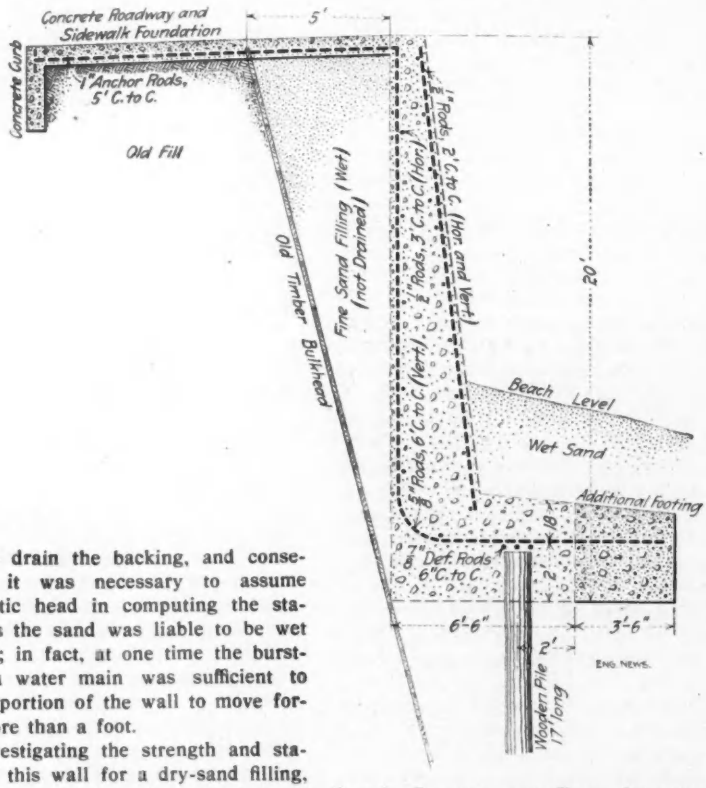

FIG. 1. ORIGINAL AND FINAL SECTIONS OF RETAINING WALL, ALLENHURST, N. J.

In investigating the strength and stability of this wall for a dry-sand filling, none of the usual formulas could be used to determine the proportionate amount of load taken by the old bulkhead and that taken by the wall itself, and various engineers to whom this problem of distribution of earth pressure was referred, arrived at widely varying results. In view of the fact that the old bulkhead was undergoing continual deterioration, it was considered to be only a question of time when the entire earth pressure would have to be taken by the wall itself.

At the time the matter was referred to the writer, a section of the new wall had already been constructed and part of the refilling begun. The writer advised the contractors not to proceed with the construction of the wall unless some means were taken to increase its stability, and made the following recommendations:

First, that anchor rods be run from the reinforcement in the wall through the old bulkhead into the old bank. Second, that the base be widened at its outer end to at least 10 ft. Third, that reinforcing rods be run from the upper part of the reinforcement at the rear face of the wall, through the concrete foundation of the proposed adjacent sidewalk, and these rods anchored into the opposite sidewalk curb. Against strong opposition, the contractors succeeded in having several of these recommendations approved and reinforced the wall as shown in the corrected section in Fig. 1.

A month later, the writer was again consulted by the above mentioned contractors in the matter of a design for retaining wall a little further along the coast, at Deal Beach, N. J., and submitted a design of a reinforced-concrete T-wall of standard design. In order, however, to secure a wall which would be adequate for the purpose and be more economical than the ordinary reinforced-concrete retaining wall, the writer made a number of studies on different types of walls and concluded that it would be perfectly feasible and more economical to use steel sheet piling, well driven into the foundation soil, securely anchored into the original bank, properly braced and protected from the disintegrating influences of the elements by means of a concrete facing and a bituminous cement mortar backing.

Computations made for walls of various heights showed that for supporting banks under 10 ft. in height the regular type of reinforced-concrete T-wall is the more economical. For a bank 10 ft. in height, the cost of both types is about the same. For supporting banks over 10 ft. in height, the sheet-piling wall is the more economical, and the economy over reinforced concrete increases with the height. The estimates were all made for the corrugated type of sheet pile, using figures furnished by the Wemlinger Steel Piling Co., for their corrugated pile.

The accompanying tables show the practical sizes for which these walls are adapted. In Table I, detailed computations are given from which the cost per running foot of the steelwork in place is deduced. Table II gives the cost of the sheet piling in position, including concrete work, and also the comparison with the cost of reinforced-concrete walls to support banks of equivalent height.

The cost per foot given in Table I does not include the cement facing or backing. In order to secure the maximum economy in placing a facing against the sheet piling, which would be adequate to protect same from both corrosion and temperature disturbances, the writer took up the matter with the makers of the "cement gun." With this apparatus an excellent cement mortar 1½ in. thick could readily and quickly be put on the piling at a cost of about $1.50 per sq.yd. This price includes a triangular metal mesh, securely wired to the sheet piling, which will hold the cement facing without any danger of its subsequent disturbance.

Excellent work has been done with the cement gun in placing coatings on iron work, even without any wire mesh to hold the same, and no fear need be enter-

tained for the adequacy of such a coating to prevent corrosion of the metal. The coating itself, applied under great pressure, is very dense, and by the addition of one of the good repellant waterproofing compounds to the mesh it can be rendered perfectly non-absorbent.

That portion of the steel sheet piling which is to be underground can readily be protected from corrosion by means of a good coating of one of the numerous bituminous waterproof mastics which are immune to the action of sea water. Further assurance of the durability of this type of construction may be secured by the use of sheet piling made from non-corrosive iron, such as that known as "American Ingot Iron."

Covering the back face of the sheet piling with such a mastic, and also the subsurface portion, will cost in the neighborhood of 30 to 50c. per sq. yd., and in Table II is given the total cost of the wall, including the protection coats as well as the concrete required for the anchor rods, coping, etc. (but excluding refill).

FIG. 2. STEEL SHEET PILE RETAINING WALLS BEFORE FILLING

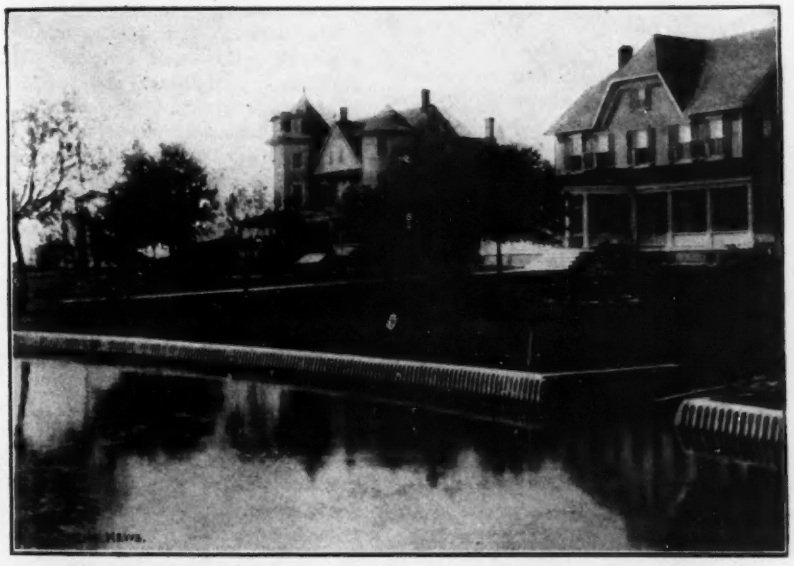

FIG. 3. FINAL APPEARANCE OF STEEL SHEET PILE RETAINING WALLS WITH CONCRETE COATING

TABLE II. COMPARISON OF COST—SHEET-PILING AND REINFORCED-CONCRETE RETAINING WALLS

(Refilling not included)

Corrugated Sheet-Piling			Height of Bank Supported	Reinforced Concrete								
Cost per lin. ft. of wall				Cost per lin. ft. of wall			Principal Dimensions					
							Stem			Footing		
Steel in Place See Table I	Concrete Protection, etc.	Total Cost, Including Contractor's Profit, etc.		Total Cost Including Bearing Piles, etc.	Cu.Ft. of Concrete per Foot of Wall	Total Depth to Foundation	Width of Top	Width of Bottom	Width of Base	Thickness at Ends	Thickness at Stem
$ 3.18	$1.00	$ 5.00	4 ft.	$ 3.50	4 cu.ft.	6 ft.	6 in.	8 in.	3.0 ft.	6 in.	12 in.
4.43	1.40	7.00	6	5.00	8.5	8.5	6	10	4.5	6	14
5.46	2.00	10.00	8	7.50	15.0	11.0	8	14	6.0	7	17
6.74	3.00	12.00	10	12.00	23	13.5	9	19	7.5	9	20
8.07	4.00	14.00	12	18.00	40	17.0	10	26	9.5	11	28
14.73	5.00	22.00	15	27.00	60	20.0	12.0	32	12.0	12	36

TABLE I. DETAILS OF COST OF SHEET-PILING RETAINING WALLS

(Detailed estimate of cost of retaining walls of different heights, excluding concrete protection. Figures on a basis of a 30-ft. section of wall).

Height of bank supported, 4 ft.	
Total height of wall, 8 ft.	
Sheet piling, 240 sq.ft. @ 28c	$ 67.20
Hauling, 1800 lb. @ 10c	1.80
Driving, 240 sq.ft. @ 4c	9.60
Coping, 2 angles, 3x3x$\frac{1}{4}$ in. (4.91 b.) 334 lb. @ 5c	16.70
	$ 95.30
Cost per ton	$ 3.18
Height of bank supported, 6 ft.	
Total height of wall, 11 ft.	
Sheet piling, 330 sq.ft. @ 29c	$ 95.70
Hauling, 2480 lb. @ 10c	2.48
Driving, 330 sq.ft. @ 4c	13.20
Coping, 2 angles 4x3x$\frac{5}{16}$ in. (7.2 lb.), 432 lb. @ 5c	21.60
	$132.98
Cost per foot	$ 4.43
Height of bank supported, 8 ft.	
Total height of wall, 14 ft.	
Sheet piling, 420 sq.ft. @ 29c	$121.80
Hauling, 3150 lb. @ 0.10c	3.15
Driving, 420 sq.ft. @ 4.5c	18.90
Waling, 2 channels, 3 in. x 4 lb., 240 lb. @ 5c	12.00
Tie rods, 3–20 ft. x 1 in. ro.; 160 lb. @ 5c	8.05
	$163.90
Cost per foot	$ 5.46
Height of bank supported, 12 ft.	
Total height of wall, 17 ft.	
Sheet piling, 510 sq.ft. @ 29c	$147.90
Hauling, 3825 lb. at 10c	3.83
Driving, 510 sq.ft. @ 4.5c	22.95
Waling, 2 channels, 5 in. x 6.5 lb.; 390 lb. @ 5c	19.50
Tie-rods, 3–20 ft. x 1 in. ro.; 60 ft. @ 2.67 lb., 161 lb. @ 5c	8.05
	$202.23
Cost per foot	$ 6.74
Height of bank supported, 12 ft.	
Total height of wall, 20 ft.	
Sheet piling, 600 sq.ft. @ 29c	$174.00
Hauling, 4500 lb. @ 0.10c	4.50
Driving, 600 sq.ft. @ 4.5c	27.00
Waling, 2 channels, 6 in. x 8 lb.; 480 lb. @ 5c	24.00
Tie-rods, 60 ft. x 1$\frac{1}{4}$ in. ro. @ 4.17 lb.; 250 lb. @ 5c	12.50
	$242.00
Cost per foot	$8.07
Height of bank supported, 15 ft.	
Total height of wall, 24 in.	
Sheet piling, 720 sq.ft. @ 35c	$252.00
Hauling, 980 lb. @ 5c	4.90
Driving, 720 sq.ft. @ 5c	36.00
Channel waling, 2–12 in. x 40 lb. beams; 1200 lb. @ 5c	60.00
Tie-rods, 20 ft. long; 1500 lb. @ 6c	90.00
	$442.90
Cost per foot	$14.73

Investigations show that anchor rods in sand filling are able to resist considerable pull by frictional resistance. In determining the diameters of the reënforcing rods given in the table, reasonable allowance was made for said frictional resistance.

In order to make the matter clearer to the reader, the accompanying sketches and photographs are reproduced, Fig. 3 showing the general appearance of the walls without concrete protection.

Fig. 5 shows the appearance of the face of a corrugated sheet-pile wall with concrete facing running parallel to the corrugations. This is more economical than filling up the corrugations and finishing in plane face. The coping also answers for a foot-walk and as a means of keeping sheet piles in alignment. It may also serve to carry a balustrade.

Sheet-pile retaining walls have been constructed in many parts of Europe, where they have been found economical and advantageous. Some important advantages resulting from the use of steel sheet piling for such installations are the rapidity of construction, freedom from excavation troubles and elimination of forms required in concrete construction, and they can be placed in almost any kind of weather.

The general contractor has very little to contend with, as he can readily sublet the driving of the piling to concerns specially equipped for this work; he can also sublet the application of cement facing to the cement-gun companies, and there remains for him only the application of the bituminous protection coats, placing the anchor rods, anchor plates, coping and refilling. Furthermore, the facing can be applied as quickly as the sheet piles are driven, the whole construction proceeding with great dispatch.

Protection Works in Paris—The level of the Seine is already rising, and the weather conditions point to a continuance of this state of things; but, for the moment, there is no reason to forecast a repetition of the disastrous floods of 1910. These followed upon an exceptionally wet summer, when the subterranean water everywhere was at a very high level. The past summer was remarkable for the longest period of drought ever recorded, and it may, therefore, be supposed that the absorption of rains may prevent the rivers from overflowing their banks. Nevertheless, this does not justify delay in carrying out the protective works in Paris, which were proposed by a commission nearly 18 months ago. The works entailing comparatively small cost are well advanced. On the whole, everything seems to have been done with the limited funds available for this purpose. As for the more important works, the various projects are still under consideration. These would entail a total expenditure of $60,000,000. The whole question now depends upon how much of this will be contributed by the state. Following upon the loan of $180,000,000 for the embellishment of the city, the raising of further funds is by no means an easy matter.—"The Engineer," London.

The Future Development of Irrigation*

By Samuel Fortier†

The building of irrigation works is far in the front and the settlement of irrigatable lands is far in the rear. There are today 5,000,000 to 6,000,000 acres supplied with water, but unirrigated for lack of settlers. In addition to these areas that await settlement, there are fully 10,000,000 acres included in partially completed irrigation projects, the managers of which are anxiously looking forward to the time when the water will be in the canals and the settlers on the land. We naturally compare this total acreage, which is to be opened to settlement in the next seven or eight years, with the rate of settlement of the past decade. In 10 years of good times we have added to the irrigated area of the West but 6,200,000 acres. In other words, in order to bring settlers to the 15,000,000 acres of lands which are ready or will be ready to be served by irrigation canals in the next seven or eight years, we will have to procure settlers about three times as fast as we have secured them in the past decade.

More consideration must be given to those features of irrigation which directly concern the irrigator. It is now our duty to teach the man already on the land how to get higher returns from the areas already open to settlement. Throwing open new areas will not solve the problem. We must demonstrate increased returns from more extensive cultivation, better methods of applying water, more wisdom in planting and in harvesting. The West must not place on the industrious settler a burden greater than he can bear. Already the price of land under way of the irrigation enterprise is more than he can pay for. Raise it a little higher and he will stay at home.

The value placed upon the farm lands of the United States by their owners has increased 111% in 10 years, but the value of lands in 11 of the far Western states has increased in the same time 203%. Only a little more inflation is needed in some irrigation districts to burst the bubble created by land boomers.

The rapid increase in the value of irrigated land applies with equal force to the value of water. Enterprises which charged $20 an acre for a water right a dozen years ago have been followed by others which charge double and treble this amount. There is, however, this difference between the two: The value of water is not fictitious. Its upward trend in price has been due to the fact that the supply available for future use is becoming every year less and less. We shall probably never see the day when water will sell for less than it has in 1911. In the states where irrigation is practiced, there are in improved farms 173,000,000 acres, but of these, less than 14,000,000 acres are irrigated.

In many states of the West, progress in irrigation is being retarded and costly investments rendered insecure by the lack of proper state legislation. Some of these urgently needed laws are clearer definitions in regard to the flow of water in streams and its use in irrigation. Colorado, at the close of 40 years of wonderful achievements in the reclamation of her arid lands, is going back once more to the irrigation primer in an effort to find out the meaning of direct irrigation. It may cost the farmers of this state a million or more dollars to find out whether winter irrigation should be defined as direct irrigation or merely the storage of water in the soil.

Again, if priorities are to hold on the waters of streams lying wholly within the state lines, they should hold also on interstate streams. A law so general as that of priorities should not become inoperative by crossing an imaginary line which separates two political divisions. Western states, through their respective legislatures must also get behind the irrigation bond. If it is not feasible to guarantee the irrigation district and Carey Land Act project bond, it should be safeguarded by state officers in every possible way. Failing this, such bonds are likely to be discredited and thereby tarnish the good name of Western states.

The need of better and wiser irrigation laws is not more urgent than that of better and more efficient administrative systems. The state irrigation engineer, if not the nominal head is usually the active head of such systems. When this office is kept out of politics and the incumbent given a long term and a fair salary, good work may be expected, providing the law under which he is operating is satisfactory. I can see no good reason to believe that progress in the decade which lies before will be less rapid than in the decade which is past. I have merely called attention to a few things which may retard development unless adequate measures are adopted to safeguard all interests. Some of the most important of these are: (1) The speedy settlement of land now under ditch, (2) the giving of additional aid to settlers on irrigated farms, (3) a readjustment of land values (and more particularly orchard-land values), (4) a more economical use of appropriated water supplies, (5) broader and better irrigation laws by Western states, and (6) more efficient administrative systems.

*From a paper read at the nineteenth National Irrigation Congress, held at Chicago, on Dec. 5-9, 1911.

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The First Transandine Railway

By F. T. McGinnis*

After many years of study and preliminary work the first South American transcontinental railway was opened in the Spring of 1910. This article describes the many projects which were attempted and the final completed construction.

*General manager, Ferro-Carril Transandino, Los Andes, Chile.

The completion of the Summit Tunnel in April, 1910, connecting the Argentine and Chilian Transandine Railways, was an interesting event for several reasons, the most important being that it made possible an all-rail route from the Atlantic to the Pacific Oceans, the first in South America. The railways making up this route are the Buenos Aires & Pacific, Argentine Great Western, and Argentine Transandine, in the Argentine Republic, and the Chilian Transandine and State Railways of Chile in the Chilian Republic.

The idea of a transcontinental railway in South America was discussed by the two governments and by private parties about the middle of the last century, but nothing was attempted until 1872, when the Clark brothers secured concessions from both governments, and as contractors constructed practically all of the line with the exception of the State Railways of Chile.

Due to many delays in construction, caused by revolutions, panics, etc., the actual work of construction extended from 1872 until 1893, when it was abandoned by the Clark brothers on account of financial difficulties. When work was stopped there remained to be completed to give an all-rail route from Buenos Aires to Valparaiso, about 22 miles on the Argentine side, and 35 miles on the Chilian side. The Argentine Transandine Ry. Co. continued the work and completed the line to Las Cuevas, the tunnel mouth on the Argentine side. Nothing was done on the Chilian side until 1904, when the Chilian Transandine Construction Co. was formed to take over the work. This company, under a new concession from the Chilian government, commenced work in 1905, and finished the Chilian side, including the Summit Tunnel, in April, 1910.

In the construction of the transandine railways, the engineering has been interesting, due to the fact that it was decided to adopt the rack system for the heavy grades rather than to develop, and the results are best seen on the Chilean Transandine Railway, as the work on the Argentine Transandine did not present great difficulties. The adoption of a rack system for a railway that forms part of a transcontinental line, and which crosses a range of mountains as formidable as the Andes, was a radical departure from ordinary methods, but at the same time the general formation of the range does not allow construction with light grades except at an almost prohibitive cost, and it will take time to determine if the rack system is the proper one for such conditions. It will be interesting to follow the workings of the transandine railways for the next few years.

The combined Argentine and Chilian Transandine Railways have a length of 154 miles and extend from Mendoza, Argentine, to Los Andes, Chile, and form the entire mountain division of the transcontinental line—the Argentine Transandine having 110 miles and the Chilian Transandine 44. The gage is 1 m. (39.37 in.), with a maximum grade of 2% for the adhesion. When the grade exceeds this the rack is used. On the Argentine Transandine, the maximum grade for the rack is 6%, while the Chilian Transandine uses 8% for its maximum, neither lines compensating for curvature, which is about 300 ft. radius as minimum for adhesion, and 500 ft. radius minimum for the rack.

Mendoza on the east side, and Los Andes on the west side, of the main range, have practically the same elevation of 2700 ft., while the Summit Tunnel has an elevation of 10,500 ft. On the Argentine side it was not difficult to overcome this difference in elevation, as the line ascends the valley of the Mendoza River until reaching Las Cuevas, and in the 110 miles it has a gradual rise for practically the entire distance, so that it was only necessary to use the rack for short intervals, the longest being two miles, and the total amount of rack being eight miles with grades varying between 4% and 6%. Part of the rack could have been avoided, as they have used adverse grades at many points.

The Chilian side presented the difficulty, as it was necessary to overcome the same difference in elevation in 44 miles, and the present constructed line has 13 miles of rack with grades varying between 7% and 8%, the longest section being six miles with an average of 7.4% grade.

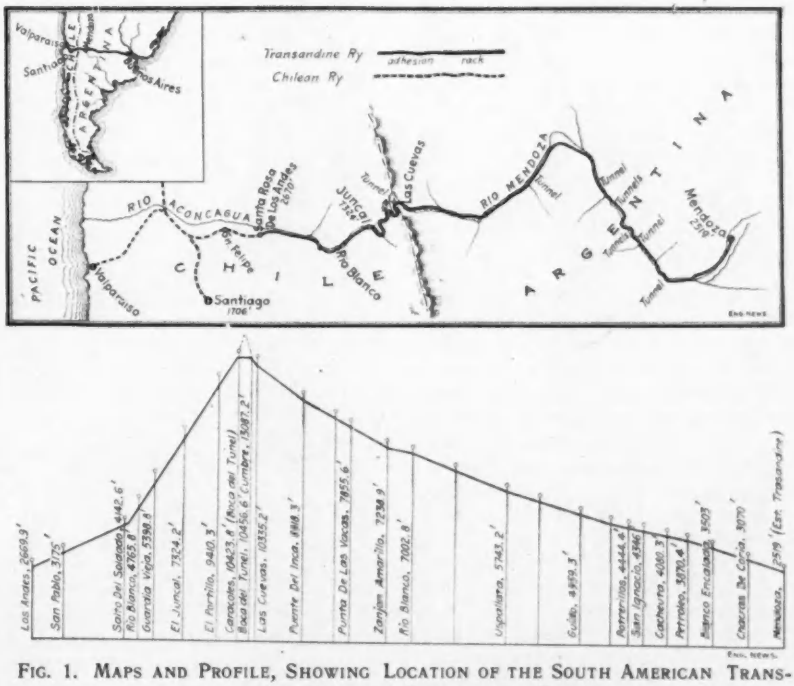

FIG. 1. MAPS AND PROFILE, SHOWING LOCATION OF THE SOUTH AMERICAN TRANSCONTINENTAL RY. WITH TRANSANDINE TUNNEL

The projects presented for the construction of the Chilian Transandine were many, and were the results of studies made during a period of 30 years by many different engineers. They include projects for adhesion for the entire distance, combined rack and adhesion, and cableway. The main range was explored, but all reports favored the adoption of a line to follow the Mendoza River valley in Argentine and the Acon-

cagua River valley in Chile, tunneling the main range at the head of the two valleys.

On the Chilian side the Aconcagua valley runs east to west from the main range to the Pacific Ocean, but it is a cañon until reaching a point some seven miles east of Los Andes. At this point the cañon widens into the valley. At Juncal, some six miles west of the summit of the main range and 30 miles east of Los Andes is the junction of the Aconcagua and Juncal cañons, the latter joining from the south, and which runs parallel to the main range for some 10 or 12 miles, the head of the cañon being lost in the broken country around the peak of Tupungata. The Juncal cañon is the larger of the two, and for some six or seven miles has a fall of about 3%.

The elevation at Juncal is 7200 ft. The Aconcagua valley from Juncal to the main range rises some 3300 ft. in four miles; however, the rise is not regular, as the valley for this distance contains five benches which have been formed by the immense falls of rock from the cliffs, extending entirely across the valley and spaces between have, in time, been filled with rock and gravel carried by the water from the melting snows.

To locate and construct the line from Las Cuevas on the east side of the range, with an elevation of 10,500 ft., to Juncal on the west side with an elevation of 7200 ft. with the main range between, with its elevation of 13,000 to 14,000 ft., was the problem that confronted all.

The original plan, known as the Waring-Davis, was an adhesion line with 3.7% maximum grade which developed in both the Mendoza and Juncal valleys and tunneled the main range at an elevation of 11,650 ft. with a tunnel two miles long. This gave a line 37 miles long between Las Cuevas and Juncal with part of it above snow line and in very broken country. It was doubtful if such a line could have been maintained, so this project was abandoned.

Afterward, all plans showed long tunnels from Las Cuevas to Juncal, the length varying from 8 to 11 miles, according to the point of starting and finishing. Some of the plans show the line coming out in the Juncal valley above Junction, others showing tunnels taking the shortest possible distance between Cuevas and Juncal. Practically all use 8% as maximum grade, using rack for that section.

One cable line was proposed using a 25% grade from Juncal to within a few miles of the summit with a tunnel through.

None of the projects presented was accepted, although studies were continued, and in 1888 Mr. Schatzman, chief engineer for the contractors, Clark Bros., presented a project which was adopted. The idea of the Schatzman project was to protect the line from heavy snows and avalanches which occur in severe winters, and to accomplish this it was found necessary to locate the line in tunnel for the section Las Cuevas to Juncal. Unlike other projects, Schatzman did not endeavor to get the shortest tunnel, but he located the tunnel to follow the general formation of the valley and also projecting a spiral to secure elevation. Of the 10 miles projected, eight miles were tunnel, the other two miles being development in the Juncal valley. The location was so made that it was really five tunnels of varying length, but the distance between being so small, only a few feet, that for all practical purposes it could have been considered one tunnel. The location allowed work to proceed at ten different points, and while the spiral tunnel was within the mountain it was reached by two lateral tunnels driven from the cliffs in the valley. The maximum grade was 8%, and it was intended that electric locomotives were to have been used on this section. Work was started and some progress made, when the work had to be abandoned by the contractors in 1892.

The Chilian Transandine Construction Co. was formed in 1904 to finish the line started by Clark Bros. However, in making the new surveys, it was decided to abandon the Schatzman project and reduce the length of tunnels as much as possible. By developing farther up the Juncal valley it was found possible to utilize the various benches in the Aconcagua valley and reach the summit in a distance of 11 miles, of which eight are rack with a grade of between 7% and 8%. The total length of tunnels is 3.10 miles. The new location also gave a short distance without rack, and a siding about four miles from the summit. Work was started in 1905 and finished in April, 1910.

From Juncal to Los Andes the line follows the Aconcagua valley, using rack for a distance of six miles, in the 10 miles between Juncal and Rio Blanco. From Rio Blanco to Andes the line is adhesion with a 2.50% maximum grade.

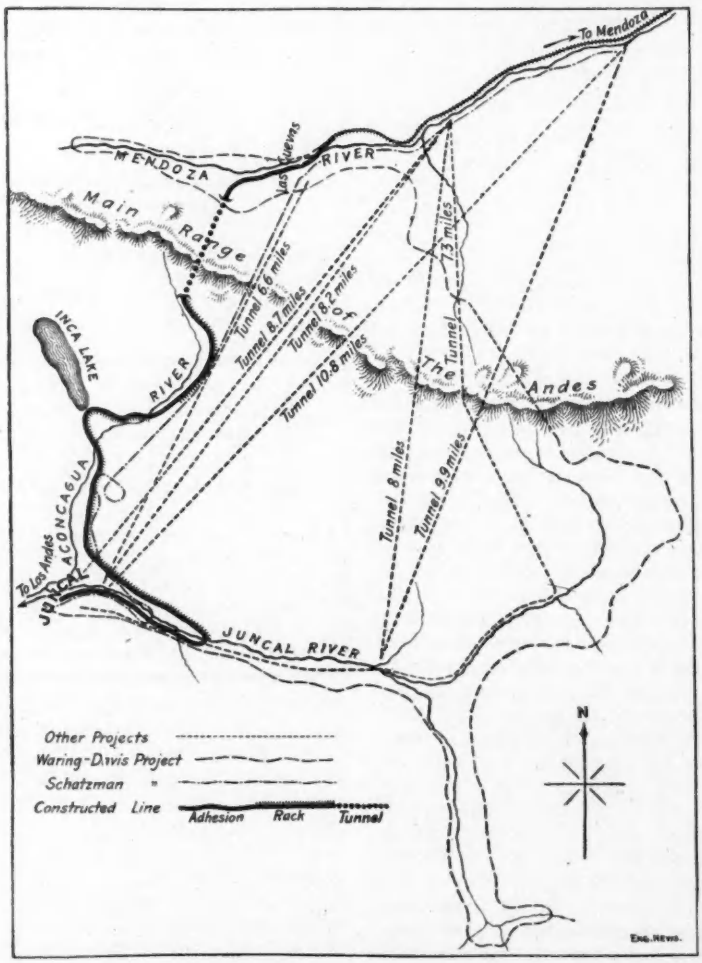

FIG. 2. SKETCH SHOWING VARIOUS PROJECTS FOR PASSING MAIN RANGE OF THE ANDES

The Abt system of rack has been adopted, using three bars, in place of the two bars as used in many lines. The development of the combination rack and adhesion locomotive is interesting, as the locomotives now used weigh 90 tons. Experiments have been made with three different types, the Abt type, the Kitson-Meyer, which has two trucks working independently, one with the simple engine, the other with the axles carrying the rack pinions, and the Mallet type. The Mallet type gives the best results, as one frame carries three axles with rack pinions, and the other frame an eight-wheel coupled simple engine. On all engines 200 lb. steam pressure is carried.

Operating the line is still somewhat of an experiment, as it has been impossible to determine the best and most economical type of locomotive. The winter months, with severe storms and strong winds, make it difficult to keep the line open for traffic at all times. The snow sometimes reaches a depth of 30 ft. on the line, and while it is expected to overcome this difficulty in time by the construction of snowsheds, the work of keeping the rack free from ice and snow is the most serious problem. The teeth on the rack axles of the engine soon press the snow into a solid mass between the rack bars, and unless this is removed rapidly there is great danger of the ice in the rack bars causing the engine to mount, which destroys the bars and steel ties. As the storms last at times from 30 to 50 hours, and with only short intervals of calm, it is at times impossible to clean the rack during intervals, especially when there is a strong wind which drifts the snow into the cuttings faster than it can be removed. As the two winters in which the road has been operated have not been severe ones, it has been possible to maintain the traffic with only short interruptions, and it remains to be seen if the traffic can be maintained throughout a severe winter.

The traffic at present is principally passenger, with a small percentage of cattle from Argentine to Chile, but with the opening of the Panama Canal, the Transandine Railways will no doubt offer facilities to travelers from the United States to Argentine and Uruguay as the shortest time, for the trip may then be made by steamer from New York to Valparaiso and by the Transcontinental Line from Valparaiso to Buenos Aires.

The Fire Underwriters' Report on Muskegon, Mich., which was issued in December, says in regard to the building inspection:

No building inspector. Laws very inadequate and not enforced. Fire limits district too small; inferior construction permitted. Construction poor; large proportion of frame buildings in business district.

Muskegon has about 24,500 population, with much manufacturing. The average number of fires is stated to be very high, but with moderate losses.

Irrigation by Pumping in New Mexico*

By Willard E. Holt†

New Mexico has practiced irrigation successfully since the latter part of the 16th century, so that we claim nothing new except improvement in method.

Aside from the area that has and can be reclaimed by harnessing our rivers and streams, we have nearly half a million acres of the richest soil that is, or may be, successfully irrigated by underground waters pumped from shallow depths, 35 to 100 ft. Of this vast area, not over 5% has been put under cultivation, but that 5% has demonstrated the guarantee of wealth to the man who has the cash or credit to buy the pump and applies himself with energy and intelligence. In every county of the new state there are areas that are being or may be reclaimed at enormous profit by the new proved system of pumping for irrigation.

At Roswell, in the great Pecos Valley, hundreds of artesian wells tap the underground waters, and many pumps are also in use. A single pumping proposition near Roswell includes 13,000 acres, with 28 miles of electric transmission lines connecting the motor-driven pumps.

The Portales region can boast the largest central irrigation power plant in the United States, where farmers are pumping on the coöperative basis, the original cost being $35 per acre, but the cost of maintenance has thus far been but $1.50 per acre. The longest transmission line does not exceed 18 miles and the area that will eventually be reclaimed will exceed 150,000 acres.† In the Estansia Valley the cost of an acre-foot of water is about $1.75. Their products this year show 1200 lb. of beans per acre, 200 bu. of potatoes, with other crops in proportion; and truck farming producing $300 per acre or better.

The Mimbres Valley is located in the southwestern part of the state and lies largely in Luna County. It is surrounded on every side by mountain ranges which effectually protect it from severe storms, an approach to a cyclone never having been known. Its level area is well described in a recently published report of Hon. Charles D. Miller, territorial engineer, which says:

> Estimates of the possibilities of this valley place the figures of irrigable area from wells producing from 500 to 1200 and even 1500 gal. of water per minute at 100,000 acres. To this area it is conservatively estimated that there may be added 100,000 acres irrigated from wells producing 500 gal. down to possibly 200 gal. of water per minute.

The valley has an underground basin filled with water filtered for many miles through sand and gravel. The government analysis last year of the water used by the Deming city water-works, which is a part of this underground flow, gave 30 parts total solids, chiefly magnesia and iron, to 100,000 parts of water. Without chemical treatment of any kind, this water is used for every purpose scientific or domestic, and is applied direct from the pump with absolute safety to every form of plant life, which means everything in the vegetable kingdom, outside of citrus fruits. Its quantity may be most easily and quickly understood when we say the report of a government engineer in charge of irrigation investigations, this year, said: "If 300,000 acre-feet were withdrawn from the underflow in one year, a condition almost impossible, it would lower the water plane below but 3.5 inches."

From this underground sea more than 200 pumps, ranging in capacity from 200 to 2000 gal. per minute, are truly making the desert blossom as the rose.

A well, pump and 35-hp. electric motor, sufficient to successfully irrigate 150 to 200 acres, costs $2300 to $2600. The same well costs from $400 to $600 more if the pump is driven by a 40-hp. gasoline engine. A crude-oil engine is slightly more expensive than either, which is overcome by a cheaper operating expense.

Computing the cost of 100 or more large and small successful pumping plants, it costs ½c. to pump 1000 gal. of water, a season's irrigation, costing from $3 to $9 per acre, according to the amount of water required for various crops and the skill of the irrigator. These figures are based on electricity at 3c. per kw., engine naptha at 12c., and crude oil at 6c. per gallon.

*Abstract of a paper read at the National Irrigation Congress, held in Chicago, Dec. 5-9.

†Deming, N. M.

‡Engineering News, Feb. 16, 1911.

The Total Exports of Tin from China in 1910 amounted to 14,351,108 lb., as compared with 9,931,775 lb. in 1909, and 10,635,345 lb. in 1908, the high output for the last-mentioned year being due to interruption in export due to floods in 1907. The export of tin from the Kotiou mines is practically all to Hongkong, the output of these mines accounting primarily for 96 to 98% of the exports of all China, and actually accounting for more than that proportion in view of the fact that much of the small balance exported from other Chinese ports is Yunnan tin, originally received from Hongkong and reëxported. About half of the tin received in Hongkong—about half of China's output of tin—is reëxported to Chinese ports and consumed in China. However, all of the increased output of Chinese tin is going to Europe and the United States, as Chinese ports took less tin last year than the year before.

It is reported by the U. S. Consul General at Hongkong that this increase in the output of tin from the mines in Yunnan Province is due to the introduction of German technical supervision and machinery.

Sewage Bacteria and Odors*

By George W. Fuller†

The bacterial flora of sewage may give rise to offensive odors, either in the collection or the disposal system. Methods of guarding against these odors are described. Odors due to sulphuretted hydrogen are given particular attention. Finally, it is pointed out that odors from sewage fall in the domain of esthetics rather than health.

*A portion of Chapter III of a forthcoming book by Mr. Fuller, entitled "Sewage Disposal with Special Reference to American Experience and Practice," to be published in 1912 by the McGraw-Hill Book Co.

†Consulting engineer, 170 Broadway, New York City.

The term "sewage bacteria" is here used in a broad sense, intended to cover the results not only of the protoplasmic action of vegetative cells, but also of the unorganized ferments or enzymes. Perhaps it would be well from a strictly biological standpoint to include with the bacteria such other micro-organisms as are capable of effecting the decomposition of sewage along aërobic and anaërobic lines.

Bearing in mind that all sewage is decomposed by bacteria until ultimately the organic matter is humified or mineralized, we will here deal with the question of its unstable as compared with its stable organic constituents. That is, further discussion will now be given to what the bacteria accomplish with the unstable portions of sewage and to the relation which their transitional and end results have to nuisances, particularly bad smells.

Relation of Decomposition to Nuisances

Consideration of practical sewage-disposal projects quickly forces attention to the nuisance question. Briefly, the principal nuisances may be classified generally in two groups, as will be detailed subsequently. The first relates to the effect of the bacteria themselves in contaminating waters and shellfish. The second involves the effect of the odoriferous products of decomposition. Exhaustion of oxygen in waters receiving sewage is an important allied matter, particularly in its relation to fish life, as will be noted under discussions upon the disposal of sewage by dilution in streams and lakes.

The bacteria of sewage are always present in the untreated product and frequently include some germs of disease. Their disposal relates to matters of filtration and sterilizaztion.

In the disposal of sewage in works of modern construction, it is necessary to give special attention to the question of odors. Large quantities of decomposing organic matter naturally suggest some odor, and to keep it within narrowly confined limits is an undertaking requiring much care, both in the design and maintenance of disposal works.

We shall consider in this chapter the bacteria in their capacity to bring about certain changes in sewage, which approach the direction of a nuisance through offensive odors unless the latter are prevented or controlled.

Oxidation and Reduction of Sewage

Aërobic and anaërobic decomposition of the organic matters of sewage bring about indirectly through biological agencies the oxidation and reduction, respectively, of various sewage compounds. This is not the case with the ordinary chemical agencies as found in sewage-disposal works, except to a limited degree under certain restricted conditions.

Atmospheric oxygen will oxidize none or but little of the organic content of ordinary sewage. Even most of the unstable organic matter is unaffected by the oxygen of the air. Years ago this was well demonstrated by numerous tests made in different parts of the world to oxidize sewage by prolonged aëration. Perhaps the best proof is to be found in the fact that many hours elapse after sewage leaves its point of origin before it loses the atmospheric oxygen contained in the water which carries away the household wastes. The gradual and time-consuming oxidation of organic matter by bacterial agencies, rather than by direct oxidation by atmospheric oxygen, is again well illustrated in the modern incubation or putrescibility tests which have led recently to more precise methods for the determination of stability.

It is true, however, that some unstable matters in sewage are capable of combining quite readily with atmospheric oxygen. The English custom of determining oxygen consumed after three and 15-minute intervals of contact with acid permanganate, illustrates the desire to measure the small quantities of fairly unstable organic matter. Some of the decomposition products, such as sulphureted hydrogen, probably are capable of combining with oxygen either as dissolved in the water or as found in the atmosphere. Most of the products of sewage, even after it has undergone more or less decomposition, may be rated as substantially stable through direct chemical oxidation. The effluent of comparatively large septic tanks upon aëration may show considerable capacity to absorb quickly in chemical combination more or less oxygen of the atmosphere.

Hydrogen is generally considered a good reducing agent, and yet it is released in septic tanks in a gaseous form, evidently incapable of effecting material reduction of the highly complex compounds in a sewage undergoing active decomposition.

Minimizing of Odors through Aerobic Decomposition

From the standpoint of preventing objectionable odoriferous products of decomposition, there is no lesson so important to be learned as that the decomposition should, just as far as practicable, be conducted on an aërobic basis.

Sewage at its point of origin, materially influenced in its composition by intestinal discharges, is not entirely lacking in anaërobic decomposition. If fecal particles undergoing anaërobic decomposition within their interior are surrounded with oxygen-containing water, however, it is quite likely that there may be some direct oxidation of some decomposition products, such, for instance, as sulphureted hydrogen. Hydrogen and carbon may be so oxidized to water and carbonic acid, respectively.

Aërobic decomposition is preferred by sewage bacteria as a general proposition to anaërobic decomposition. So long as the oxygen dissolved in the water of sewage is able to maintain aërobic conditions, there will be a minimum of complication from anaërobic decompositions. This may, perhaps, make a little plainer than hitherto the importance of conveying sewage from its point of origin to its point of disposal with a minimum time interval for the exhaustion of oxygen.

Proper Methods for Guarding against Odors in Systems of Collecting Sewers

For some thirty years, beginning with the comprehensive report outlining the scientific principles on which European sewers were built, prepared by Rudolph Hering at the request of the National Board of Health, it has been known that sewage should be brought to the point of disposal as promptly as possible and with minimum opportunity for decomposition of stranded materials within the pipes. As knowledge has increased with respect to decomposition of sewage, it has become clearly recognized that additional care should be required against objectionable odors.

[The author here urges the thorough ventilation of sewers in order to lessen the exhaustion of oxygen and to favor aërobic rather than anaërobic processes in the sewers. Untrapped house connections, or rather the omission of main

traps, is advised to this end. Self-cleansing velocities, smooth interior surfaces and flushing, as needed, are also advocated.—Editor.]

In the larger sewers it is not feasible to flush readily from automatic flush tanks, but it is practicable to keep decomposing organic matter from remaining lodged upon the interior surface of the sewers. This may be done either by hand, with a hose or flush gate, or by putting in stop-planks at manholes and allowing the sewage to build up in depth until a head is established sufficient to create a scouring velocity when released.

SEEDING—The statements above are sufficient to point out the advantage of having clean sewers. They do not fully exploit, however, the possible disadvantage of deposits within a sewer system becoming seeded with suitable bacteria so that where sufficient time elapses anaërobic decomposition may progress to the point of producing putrefactive enzymes. It is not difficult to consider conditions where stranded solid matters yield such putrefactive enzymes as may modify prejudically the character of fairly fresh sewage flowing over such deposits. The character of the sewage may, perhaps, be modified by deposits in a system, having an extreme period of flow from the head of the sewer lines to the outfall of only an hour or two, so that the effect is more prejudicial than would be the case with a sewage that has flowed for five or six hours through clean sewers.

AERATION—The introduction into sewage of more atmospheric oxygen than is left in the water supply of which the sewage was initially composed has perhaps more merit than has generally been considered hitherto for some large trunk sewers. While this would not provide substantial oxidation of organic matters, or increase the oxygen beyond the saturation point, it would afford the advantage of prolonging bacterial operations on an anaërobic basis. From the standpoint of the "oxygen balance" it would make the sewage more stable. This aërating idea is unwittingly availed of in sprinkling filters within certain limits, and constitutes one of the reasons why sprinkling filters have a greater capacity per unit volume of filtering material than contact filters. The question will be taken up in connection with the recent report of Col. Black and Prof. Phelps, with respect to aëration of sewage as a means of treatment for certain districts within the city of Greater New York.

NATURE OF OBJECTIONABLE SEWAGE ODORS

Recognizing the necessity of considering anaërobic decomposition, on account of inability to control absolutely the decomposition of sewage on an aërobic basis, it becomes important to study the decomposition products in their relation to objectionable odors.

It has been noted already that, as transitional or end products of sewage decomposition, there are a number of foul-smelling substances. They appear in part gaseous products and in part as compounds in solution. We do not pretend to know minutely as to their origin or appearance in sewage, but offer a few comments as to their characteristics as follows:

NON-GASEOUS COMPOUNDS—While sulphureted hydrogen seems to have the reputation of being the most offensive product in the decomposition of sewage, it is doubtful if this statement is correct. Indol, skatol, cadaverin, mercaptan and some other compounds are considered more repulsive than sulphureted hydrogen. Indol and skatol are found in fresh feces, and no doubt show themselves at times in sewers and sewage-disposal works. All of the products mentioned in this paragraph, other than sulphureted hydrogen, are found in sewage only in a soluble, non-gaseous state.

The sense of smell is related to the effect which gases or vaporized substances produce on entering the nostrils and coming in contact with the nerves there. This is of importance in considering the question of odors. It is not to be inferred, however, that indol and other non-gaseous products are to be left out of the reckoning. They may make their influence felt, as is true of other liquids which are malodorous, by volatilization and evaporation. We will not attempt to enter further into this question, but it should be pointed out that floating scum and deposits which are exposed from time to time may release non-gaseous substances in a way to contribute substantially to the production of bad smells.

GASEOUS PRODUCTS—Hydrogen, nitrogen, methane or marsh gas, and carbon dioxide are not considered as objectionable gases as to odor production. Ammonia may become offensive, but rarely from the concentrations found in the atmosphere around sewage works. This leaves hydrogen sulphide as the particular gas to be considered here.

Oxygen seems to be an antidote for sulphureted hydrogen to a considerable extent.

It would be of interest if we knew more about this gas and whether it is in reality a product which occurs as such in sewage to a considerable extent, or whether it is mixed with mercaptan and other products which smell badly. Mercaptan is a sulphur compound (C_2H_5SH), but sulphur is not found in indol, skatol nor other products mentioned in the group of non-gaseous odor-producing compounds of decomposition. Possibly phosphorus may frequently afford offensive decomposition compounds, but we are not informed about them. Phosphates are reduced by bacterial action, and phosphine (PH_3) is a foul smelling gas.

CONTROL OF SULPHURETED HYDROGEN ODORS

There is no known way of preventing the formation of sulphureted hydrogen, which is released from organic sewage matters by a great variety, and perhaps most kinds, of bacteria. So long as it is released into oxygen-containing water, complications do not seem to be serious, unless the conditions of decomposition are such that the gas is released so that numerous tiny bubbles, saturating their immediate surroundings, mass together into large bubbles, the buoyancy of which causes them to rise to the surface of the liquid.

There is apt to be quite an irregular dispersion of organic sulphur compounds in sewage. This feature may perhaps be quite important in explaining irregularities in the release of objectionable smells from certain sewage-disposal devices. There is good reason to believe that to some extent sulphureted hydrogen is characteristic of all sewage decomposition. It does not seem true that certain bacteria decompose sewage with the formation of marsh gas and no hydrogen sulphide, while other bacteria produce sulphureted hydrogen and no marsh gas. There may be certain conditions under which offensive gases may be released from certain operations, but not under other conditions. These comments are made, having in particular view the observation that some disposal plants produce noticeably objectionable odors on half a dozen days or nights in the course of the year, and are practically free of such odors during the balance of the time. It is, therefore, necessary to increase our energies in the study of the special conditions which occasionally prove bothersome.

Associated with the above-mentioned factor is the condition of the atmosphere at times when the odors are most noticeable as to intensity and distance from the works. Aërial nuisances as to odor vary much with the barometric conditions and wind velocity, as they affect the dispersion and oxidation of gases in the atmosphere. Thus, at many disposal plants it is found that objectionable odors are most noticeable as to intensity and distance from the plant on what are ordinarily spoken of as "muggy" days. The barometric pressure on such occasions no doubt prevents the gases, particularly a heavy one like sulphureted hydrogen, from rising as high in the atmosphere as ordinarily is the case. Furthermore, the dispersion of the gases in the atmosphere is much less rapid than usual and this perhaps prevents aërial oxidation at normal speed. Associated with this are, no doubt, a variety of other factors about which information is quite meager at present. It is, perhaps, worth mention-

ing that some of the malodorous products may not be present in a chemical state such as to promote oxidation. They may be combined with other compounds which retard the reaction with the oxygen of the air.

Regarding this subject, it will, perhaps, be well to speak briefly of the fact that at some disposal plants there are characteristic odors other than that of products of anaërobic decomposition. These odors are sometimes spoken of as being similar to laundry odors or odors resembling a raw turnip. The odor of cooking of certain vegetables is, of course, a conspicuous one under some circumstances. It is mentioned here to accentuate the thought that there are a good many decomposition products which have an individuality which is not specifically offensive, although it is noticeable and objected to by some. At the same time, such products suggest that hydrogen sulphide is not the whole story, and that it is important to study other compounds in connection with the question of objectionable odors, now classified for convenience as "hydrogen sulphide." Several features concerning the control of this type of odor will now be outlined.

ARRESTING SULPHATE REDUCTION—In the event that there are but very few species of bacteria capable of producing hydrogen sulphide through the reduction of the mineral sulphates, it may be feasible to find some way of destroying such growths. It would be better yet to find means of preventing such growths from becoming seeded in works, on account of the importance of guarding against the resulting solvent actions that disintegrate concrete and metal structures. It seems to be a fruitful field for the laboratory men to develop.

BACTERIAL CULTIVATION—Not in sewers, but under some conditions, it may be feasible to cultivate Beggiatoa and Thiothrix, which are capable of consuming hydrogen sulphide. The zone of their successful growth would be within quite narrow limits.

CONCENTRATION AND MIXING—Within certain limits it is feasible to minimize the opportunities for bacterial decomposition to produce a large quantity of sulphureted hydrogen at the same point or location. This refers not only to sewage works, but to streams and estuaries where sewage deposits have to be reckoned with. It involves the question of thorough mixing, so far as practicable, of decomposing substances and of overlying liquids. The object is to have the hydrogen sulphide formed under conditions most favorable to ready control by oxidation and precipitation.

PRECIPITATION—Sulphide of iron is a black precipitate which explains the dark color of most of the stale and septic sewages. The precipitation of this gas by iron liquors and the iron naturally contained in sewage has an important bearing upon the odor question. As stated by Mr. Morrill, the precipitation of hydrogen sulphide will not necessarily be complete at all times, so as to prevent all escape into the atmosphere, particularly where bubbles of large size are evolved. However, it is believed that it is of much importance to the actual performance of some disposal plants, such, for instance, as at Birmingham, England. There is no reason, apparently, why the use of iron salts should not be availed of for addition in a manner to control the precipitation of this gas, if need be.

OXIDATION IN LIQUIDS — Oxygen-containing water minimizes the effect of this gas in sewers, sewage tanks, streams and the like. It furnishes an opportunity for control, and the greater the depth of the overlying liquid the greater will be the opportunity for preventing gas bubbles rising to the surface. Further, at considerable depths from the surface the coefficient of absorption of gases or water is much greater, and this tends to minimize the appearance of gas at the surface of the liquid.

SANITARY SIGNIFICANCE OF OFFENSIVE ODORS—ISOLATION

Offensive odors from sewage relate, for the most part, to the esthetic and not the sanitary side of the question. It is true that some people are nauseated and perhaps debilitated by putrid odors. But the general evidence now indicates that these odors do not produce sickness to an extent materially affecting the death rate in a community. All reasonable effort should be made, however, to prevent the occurrence of bad odors.

Wide differences of opinion exist with respect to odors from sewage and sewage works. Some people are so constituted that even fresh sewage conveys to them the idea of an unmitigated nuisance. Some people actually take offense to the flow of ground water (seepage) in an outfall sewer to which no house connections have been made, in a manner similar to the sentimental objections to operating garbage incinerators while they are being dried out through the burning of coal, and before a single shovelful of garbage has been delivered to the plant.

On the other hand, there are those who are accustomed to the odors of manured fields, fish markets, meat markets, cheese factories, etc., and to whom the odor of sewage makes quite a different impression. Included, perhaps, in the latter class are those who have much to do with sewerage works.

It is certain that sewage outfalls and sewage-treatment works are not likely to smell like a flower garden, unless more attention than has ordinarily been the case hitherto is given to minimizing sewage odors and increasing the extent of the landscape gardening.

Where feasible, isolation is desirable. When it is not feasible to isolate disposal works, they should be designed and operated with the specific view of guarding against offensive odors. Methods are available for eliminating the decomposing portions of sewage so that it is not exposed to view until in a stable or humified condition.

Experience With Engineers on Highway Work in Massachusetts*

If we have been able to do anything in Massachusetts that is worth doing it is because from the start our road building has been kept out of politics and has been under the charge of skilled and able engineers and road builders. New York has $18,000,000 to spend on her roads this year. I've taken three sets of New York commissioners over our roads and in that time the head of the labor force and the engineering force and largely the labor has changed. Each commission has agreed that what was done by the one ahead of it was wrong and done for political purposes. Now what kind of roads do you suppose a state can get that way?

"While we make mistakes in Massachusetts we have minimized them by having a corps of skilled engineers. Most of our engineers have been with us ten or twelve years. We get Technology boys to make up our field parties in summer. Other states, however, get away some of our men, because they appreciate them and can pay them well. Our engineering cost is about 10% of the whole cost, but is one of the best expenditures we make, although it was the most criticized at first. It doesn't cost as much in ten years to build a good road right as it does to build a poor road. Town after town is coming to us for engineering advice, but 16 years ago the commission had to ask the towns to petition them for pieces of state road in order to expend the appropriation.

A New Automatic Stoker has just been brought out by the American Stoker Co., 11 Broadway, New York City, which has for 15 years been exploiting an underfeed stoker. The new stoker is of the inclined step-grate type, with alternate steps fixed and moving. The grate bars are cooled by interior water circulation. The movement of the grate is adjustable according to the character of the coal to be burned, with successive steps overlapping so that coal cannot sift through to the ashpit until it has traveled the length of the grate. The distribution of coal on the grate is made variable so that more coal is furnished to paths where combustion is most rapid. The company is shortly to issue a bulletin descriptive of its new stoker.

*From an address by Wm. D. Sohier, of the Massachusetts Highway Commission, before the New Hampshire Good Roads Congress, Dec. 14.

Waterproofing a Bridge Floor Over a City Water Supply

The line of the new New York, Westchester & Boston Ry. Co., now under construction north of New York City through Westchester County, passes in the city of Mount Vernon on a viaduct over the Hutchinson River, which is one of the sources of the water supply of the city. In order to avoid the pollution of that stream, it was required by the city that the railway company completely waterproof the floor of the viaduct so as to lead all rain water and train drippings from the bridge to some inoffensive location back of the abutment. The accompanying figures show how this was accomplished.

The viaduct is of the ordinary deck steel type, composed of nine plate-girder spans varying in length from 50 to 62 ft., resting on two concrete abutments, seven 30-ft. trestle bents and one single-column bent, in all a total length of over 700 ft. On account of the extreme length it is divided into four parts by three expansion joints, each of which had to be protected by a special design of waterproofing. The track structure consists of a concrete slab, reinforced transversely top and bottom with continuous bars for the full length near the bottom and for short distances over each of the four longitudinal girders at the top. It is also reinforced longitudinally in the top over each bent with heavy expanded metal to provide, in so far as possible, against the cracking of the slab over the supports, due to the deflection of the longitudinal supporting girders (Fig. 1).

The slab for each track was put in independently, and the concrete at the juncture separated by oil paper. This was done so that in the event of load on only one track the deflection of this half of the slab would not affect and crack the portion under the unloaded track. All of these precautions were to the end that as few cracks as possible be created, on the principle that the fewer the cracks in the slabs the fewer the chances for leaks.

The main waterproofing consists of four successive layers of a special waterproofing compound and felt, laid directly on the top of the concrete slab, on top of which was laid one layer of vitrified brick, again covered with waterproofing compound. Upon this surface the regular track ballast was laid. At the expansion joints the special detail shown in Fig. 2 was placed. This consists of a continuous transverse layer of sheet lead extending back into the concrete slab for about 6 in. on each side of the 2-in. expansion opening and spanning that opening with a sag, which allows the necessary movement at the joint. Above this plate there was placed a filling of non-hardening marine cement and oakum, and the whole covered with a ½-in. cover-plate.

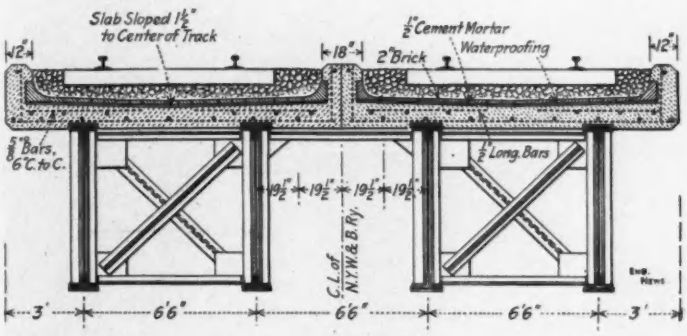

FIG. 1. SECTION THROUGH FLOOR OF HUTCHINSON RIVER VIADUCT, N. Y., W. & B. R.R.

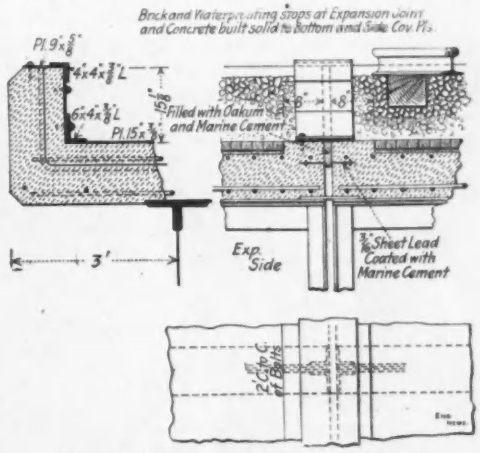

FIG. 2. DETAIL OF WATERPROOFING AT EXPANSION JOINT

The water at present flows the entire length of the viaduct and is delivered over the east abutment and there distributed to the fill. The slab under each track is, however, tapped at two points with a pipe head, screw-capped on top, so that if it should prove in future that the flow of water is not sufficient to prevent freezing and heaving of the ballast, it can be drained independently in three sections.

The waterproofing was done by the firm of F. W. Bird & Son with its own products, with the exception of the expansion joints, which were put in and waterproofed by the railway company's force, using Toch Bros. marine cement. The structure was designed by and the construction superintended by the engineering department of the railway company, with J. L. Crider as chief engineer, and A. H. Rhett as structural engineer.

The Black Rock Lock at Buffalo, N. Y., was completed on Dec. 18, 1911. This lock is 600 ft. long, 70 ft. wide, 24 ft. deep, and has a lift of 5 ft. There are five pairs of gates.

An Experimental Electric Railway Line is to be built by the Bergmann Electric Works for the Bavarian government. If it proves successful one of the existing Bavarian trunk lines is to be equipped for electric operation. The new line is to run from Partenkirchen to Mittenwald and on to the Austrian line at Griesen, 24 miles. If the trunk line from Munich to Griesen is electrically equipped, it would form part of a through route to Innsbruck. The projected hydraulic-power plant at the Walchensee is to furnish the electric power.

Sliding Railway Embankments on a line of the Austrian government railways between Zieradorf and Eggenburg were discussed by Mr. H. Raschka before the Oesterreichische Ingenieur und Architekten Verein at its annual meeting, Dec. 9, 1911. This section, 11 miles long, is part of the grade from the Danube valley to the Bohemian tableland, and has gradients up to 1%. The soil is clayey. Built originally in 1870 for single track, the line was doubletracked in 1903. Slides of banks and cuts have always given trouble, but more especially since the doubletracking. The author described the slumping of clay embankments due to imperfect drainage of the road bed, where the ballast had settled down into the fill and thus formed a water pocket. The most serious trouble, however, was a slide which occurred in 1910, affecting a 1000-ft. stretch of 22-ft. embankment on a 1:6 hillside. Here the underlying soil started a slow slip, and the embankment moved an inch per day, forming two longitudinal cracks in the center and on the downhill slope. A ridge forming 150 ft. below the bank showed the movement of the subsoil. Rock was 35 to 90 ft. below surface, and clay with occasional sand laminæ overlay it. To cure the trouble it was decided to replace the embankment by a steel viaduct on concrete and stone piers, just downhill from the embankment. This is now nearly completed; the piers go to rock, at maximum depth of 80 ft. During the work much difficulty was experienced in maintaining excavations in the slipping subsoil. (Zeitschr. d. österr. Ing. & Arch. Ver., Dec. 15, 1911.)

Safe Velocities of Water on Concrete

By Arthur P. Davis*

Frequent inquiries are made regarding safe velocities of water upon concrete, and the experience with structures of the Reclamation Service and others may be of general interest in this connection.

On the South Canal in Uncompahgre Valley, the Reclamation Service has a drop or chute where the water descends on a very steep slope on concrete, shown in Fig.1. This canal was designed to carry about 1200 cu.ft. per sec., and up to date has been in service one season, the maximum amount of water thus far carried, however, being about 300 cu.ft. per sec. With this quantity, however, the velocity exceeds 20 ft. per sec., and no damage to the concrete is perceptible, which can be attributed to this velocity. In fact, a slimy moss accumulates on the concrete under the water.

On the Strawberry project near Provo, Utah, a power plant which has been in use about two years was provided with a spillway through which surplus waters are turned and it receives all of the water from the canal when it becomes necessary to suddenly shut off the water from the plant. This spillway, shown in Fig. 2, is built on a 42% slope and occasionally received 300 cu.ft. of water per sec. The velocities are at such times above 40 ft. per sec., and thus far have caused no perceptible damage to the concrete.

The dam on Tuolumne River, near La-Grange, Calif., is an ogee overflow type of dam, giving a fall to the water of approximately 100 ft. This is believed to be the highest overflow dam in the world, and has been in service about 18 years. The basin above it, being a narrow cañon, was filled with sand during the first few years, so that the sands of the river are carried over its top by the water thus discharged and the dam has withstood an overflow on various occasions from 15 to 16 ft. in depth over the crest.

This water, when it reaches the toe of the dam, probably has a velocity of more than 70 ft. per sec. The flood of Tuolumne River flows over this dam at varying depths for six or eight months every year. The writer made a careful examination of this structure about two years ago.

The dam is built of rubble masonry, the rock used being of a very tough greenstone found at the site, which also comprises the bed of the river in the foundation and below the dam. The curved surface which the water follows on its course over the dam is built of concrete, consisting of a mixture of cement and sand with broken rock of the same tough greenstone. This concrete shows a slight wear at most points, the wear being greatest upon the sand and cement, leaving the pieces of greenstone projecting slightly from the surface, and they are highly polished.

At various points it is still possible to see the marks of the forms against which the dam was originally built, but over most of the surface some wear is noticeable, possibly reaching as much as ½ in. The wear is, of course, due to large quantities of sand which flow over the dam, and is probably greatest at low water, when the velocities are not as high as they are in the greatest flows. It is fair to say that absolutely no actual damage has been done on this dam under the high velocity to which it is subjected, and that even the slight wear shown would probably be absent were it not for the sand which the water carries.

The tunnel constructed through the south abutment of the Roosevelt Dam, designed for the diversion of water during the construction of the foundation, was built in hard sandstone occurring in strata inclined about 30° to the horizontal. The rock, while hard, was rather seamy, and it was intended before putting it to regular use to line it with steel plates; however, before this was done the contractor desired to use it for diverting the river while constructing the foundation, and it was put to such use without lining.

Gates were installed as described in Engineering News, May 30, 1907, p. 589.

By reason of a flood which overtopped the unfinished dam, the water was for some time discharged through this tunnel, under a head of about 60 ft., which did considerable damage to the natural rock in place in the perimeter of the tunnel. Though this is not an example of action on concrete, it is a very vivid illustration of what a turbulent broken up stream of water under this high velocity will do. It was necessary to close the gates and make careful repairs to the tunnel before subjecting it to further use.

During the year 1899, the North Platte River experienced the greatest flood in its history and the Pathfinder Reservoir was nearly filled in the course of the summer, although a tunnel 10x13 ft. in section was left open, as was also a culvert 6 ft. in diameter at the upper end and 4 ft. at the lower through the Pathfinder Dam, shown in Fig. 3. There were also two 36-in. pipes discharging under full

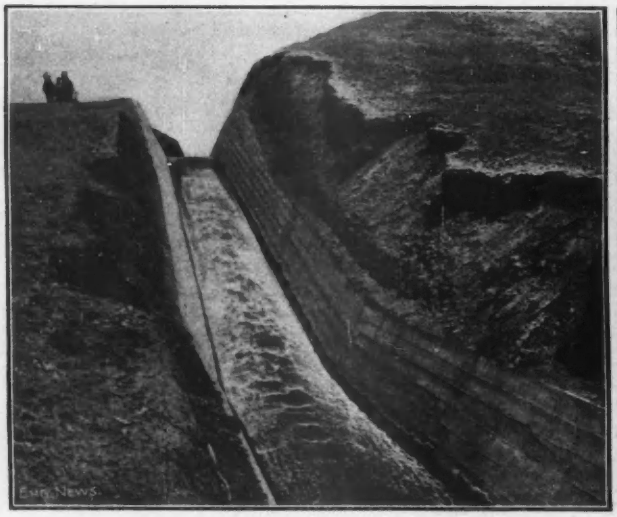

Fig. 1. High-degree Slope on South Canal, Uncompahgre Project, Colorado, U. S. Reclamation Service

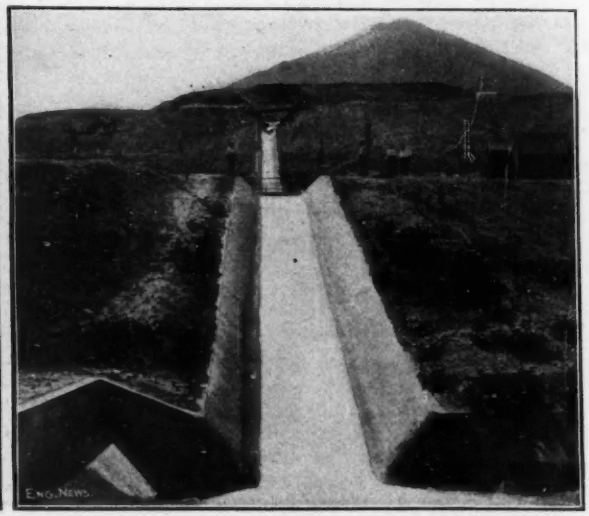

Fig. 2. Spillway, Strawberry Valley Power House, Utah

*Chief Engineer, U. S. Reclamation Service, Washington, D. C.

head at the same time. Notwithstanding all these openings, the water rose to a height of 181 ft. above the river bed, and water was discharging under a head of more than 150 ft. through all the openings mentioned from May to October, nearly six months. The Pathfinder tunnel was built in a good quality of granite and was lined with ½-in. steel plates, backed with concrete with all bolts countersunk and extra precautions taken to prevent the water getting a hold upon the lining. At the upper end of the tunnel were placed a series of four cast-iron gates, described in ENGINEERING NEWS, Jan. 2, 1908, p. 8.

The experience of those six months gives the best and most conclusive illustration known to the writer of the action of water under very high velocity. It is, of course, impossible to say just what was the velocity in any one of these conduits, but a close average was obtained by comparing the total cross-section of the conduits with the discharge of the river below the dam, and through most of the six months mentioned the average velocity of the water in these various conduits was in the neighborhood of 90 ft. per sec. The culvert through the dam, which was 4x6 ft. at its upper and gradually tapering to 4x4 ft. at the lower end, was built of concrete, and after the flow of water through it for six months at velocities from 75 to 90 ft. per sec., it was absolutely uninjured, the marks of the forms still plainly showing upon the concrete. This showed clearly that clean water gliding over concrete without impact has little erosive effect regardless of velocity.

On the other hand, the stream flowing through the tunnel, which was broken into four parts by the gates and entered a conduit of nearly double the cross-section of the gate openings where the stream was turbulent and impact was permitted, was very destructive. Nearly all of the steel lining was torn out of the tunnel, all of the concrete thus exposed was carried away and considerable erosive effect upon the granite was noted. One block of granite containing about 4 cu.yds. was turned from the side of the tunnel into the tunnel like a door, and various other evidences of the enormous force of the water were noticed.

These observations are very convincing upon two points:

1. That where clear water can be made to glide over concrete without disturbing its velocity or abruptly changing its direction, there is no practical limit to the velocities that can be permitted without harm.

2. That concrete which is subjected to the impact of water under high velocity is rapidly eroded and that under such conditions the velocities must be very carefully limited.

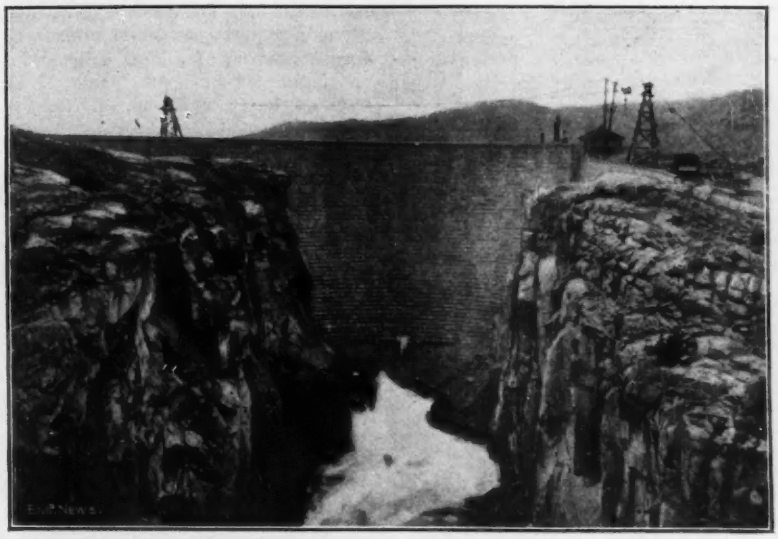

FIG. 3. PATHFINDER DAM, U. S. RECLAMATION SERVICE. VIEW FROM BELOW, SHOWING OUTLETS DISCHARGING

Gasoline Motor Cars Have Replaced Horse Cars on the lines of the Morecambe Tramways Co. in Heysham, Lancashire, England. This is a short section of about 1¼ miles. It is short and hilly and no electric power is available. The new cars are heavier than the old horse-drawn vehicles, and run at considerably higher speed so that the old light track had to be replaced. The new cars are of the closed single-deck type, seating 37 passengers. They are 30 ft. long, and 10 ft. from rail to top of roof. They weigh approximately 7¼ tons and are driven by a 60-hp., 1000-r.p.m. four-cylinder engine. Power is transmitted through a four-speed gear box to a flexible drive on the axle.

Needed Forestry Changes in New York State

"How to Save the Adirondack Forests" was the subject of a report submitted to the Campfire Club of America, about Dec. 1, 1911, by Gifford Pinchot, recently head of the United States Forest Service. The address opened and closed with the significant words: "Forestry in the State of New York is flourishing everywhere except in the woods." In explanation of this statement, Mr. Pinchot said:

> The constitution forbids the practice of forestry on state lands, and scarcely a single tract of privately owned forest, either in the Catskills or in the Adirondacks, is today being cut under the rules of practical forestry. On the other hand, within the last ten years the destruction of forests by fire and bad logging has been greater than ever before.

As to the proper means of forestry which ought to be adopted in the Adirondacks, the gist of Mr. Pinchot's remarks was to the effect that an intelligent system of selective cutting should be adopted in place of the clean cutting which is generally practiced on private land. On the public lands, no cutting whatever is permitted, owing to the provision of Section 7 of Article 7 of the State Constitution, which is as follows:

> The lands of the state, now owned or hereafter acquired, constituting the forest preserve as now fixed by law shall be forever kept as wild forest lands. They shall not be leased, sold or exchanged or be taken by any corporation, public or private, nor shall the timber be sold, removed or destroyed.

The practical effect of this article of the Constitution has been to prohibit the cutting of any timber whatever, the building of roads to make the woods accessible or the construction of camp buildings to make the woods comfortably available for private camping purposes. Mr. Pinchot suggested that the article cited be amended to read substantially as follows:

> The lands of the state, now owned or hereafter acquired, constituting the Adirondack and Catskill parks as fixed by law shall forever be kept as forest lands. They shall not be sold or exchanged or be taken by any corporation, public or private, and no timber shall be cut on said lands except in accordance with the principles of conservative forestry, nor shall the permanent forest condition of any such land be interrupted, endangered or destroyed by clean cutting or otherwise.

In conclusion, Mr. Pinchot stated that his report was based on the field work and experience of Overton W. Price, his late associate in the United States Forest Service, and his present associate in the National Conservation Commission, as well as on his own experience.

A 40-mile Sewer for Potash Wastes is planned by the potash works in the Hanover district of Germany, to conduct the waste liquors to the Weser, as the streams now used for discharge (the Leine and the Innerste) have reached the limit of pollution. The sewer is planned to be of iron pipe, with lining to resist the alkali action. (Zentralblatt der Eisen- und Metall-Röhren-industrie.)

Machines for Handling Railway Ties

By R. P. Black*

Machines for loading railway ties on cars have been developed on the Kanawha & Michigan Ry. in West Virginia and single machines can take ties from rafts in the river and load them on cars at the rate of nearly 5000 per day of 10 hours.

*Engineer of maintenance of way, Kanawha & Michigan Ry., Charleston, W. Va.

Railways built into new territory where timber is abundant, especially in mountainous country, derive a considerable percentage of their freight revenue not only from logs and the finished product of the lumber manufacturers, but from railway cross ties. After a few years the timber close to the railway is entirely cut and shipped. When this condition is reached, branch lines have to be constructed to reach the new locations of the lumber camps, and then most of the ties are hewed in the forest, or else sawed at small mills 15 or 20 miles distant from these branch lines. In mountainous and rough country, with roads unfit for hauling, the ties are floated during freshets singly or in small rafts and carried by the current down the tributary branch streams of the watersheds to the creeks, where they are stopped by booms across the mouth of the stream. They are then gathered into rafts containing from 500 to 2000 ties, which are floated during the high-water period to the river or larger stream in whose valley the railway is constructed.

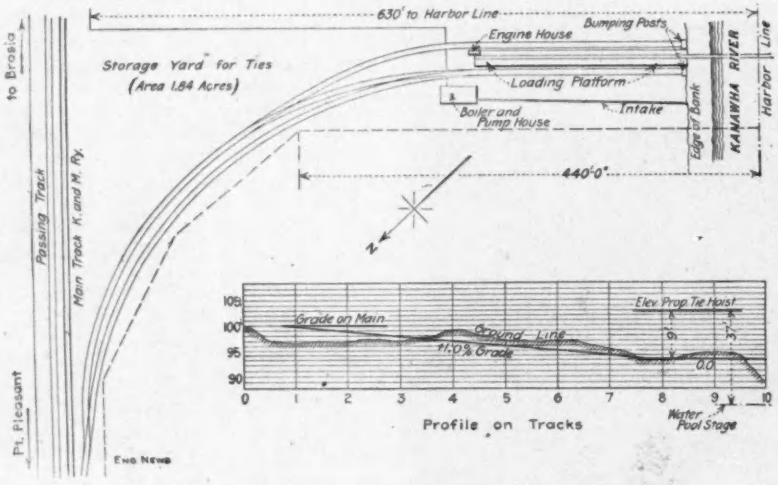

FIG. 1. PLAN OF TIE LOADING AND CONVEYING PLANT ON THE KANAWHA RIVER AT BROSIA, W. VA.; KANAWHA & MICHIGAN RY.

The rafts used in the rivers are constructed of three ties deep, three breadths wide, about 100 ft. long. The ties are securely fastened together with strips, and rudders are provided at either end of the raft for guiding to the final place of loading. By the construction of chutes or new channels a number of the smaller streams in West Virginia have been made navigable for rafting purposes during high waters. The expense of these improvements was borne by the state or federal government when warranted as a help to commerce; otherwise, by interested lumber companies.

The railway not only has to provide side-track facilities for the loading of ties by the shipper at its station points, but also to arrange means of getting the many ties out of the rivers into cars as soon as they arrive in its territory. This is not only an advantage in getting a longer haul, but to prevent the getting of this freight by competing lines which have loading facilities further down on the larger rivers where the rafts could be taken.

Several methods for taking the ties out of the river have been developed, from the primitive method of carrying them by laborers up an incline, to the modern plan of doing it by machinery. On the Ohio River, where the bank has a gradual slope, this has been done by the construction of an incline track to the river, built during low-water periods. The descent is made on a 4% grade, decreased to 1% for several hundred feet at the lower end of the track, which is well anchored to prevent floating. The cars are placed upon this track and run into the water till the body is submerged. By means of floats attached to the cars, laborers load the ties from the water into the cars. This method is expensive; it not only requires considerable labor, but does not permit of a large daily loading on account of the short length of the track on the 1% grade suitable for placing cars.

Another scheme used (but now abandoned) was an incline extending into the water, upon which a truck was operated upon a narrow-gage track. The truck, after being lowered below the water, was loaded with 10 or 12 ties and hoisted to a platform, first by a hand windlass, later by an engine. The ties were then loaded onto cars placed next to the platform. The two above plans proved unsatisfactory, not only on account of expense, but more especially due to the extra handling of the ties for inspection by the purchaser. The incline track, however, permitted of loading flats with logs and of transferring freight to boats.

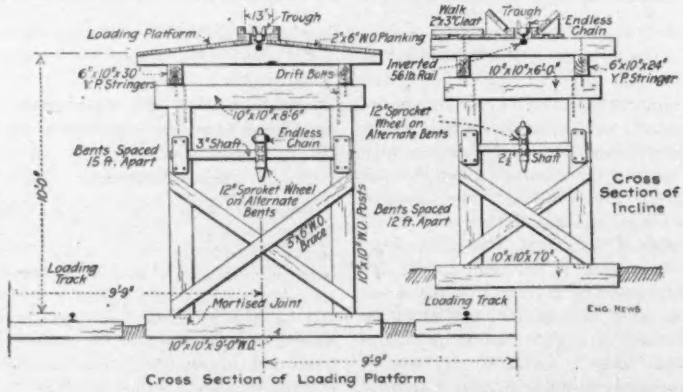

FIG. 2. TIE LOADING PLATFORM AND INCLINE WITH CHAIN CONVEYOR

The proposition in designing a suitable hoist is to obtain a large daily loading capacity with small labor expense and to permit of close inspection of each tie before loading. The Kanawha & Michigan Ry. has provided two plants for loading

ties into cars from the river, and these have been given the name of tie hoists. One is situated at Charleston, W. Va., near the mouth of the Elk River, where ties from its watershed of about 500 sq. miles are loaded. The other is at Brosia, W. Va., near the mouth of the Big Kanawha River, where ties are loaded that have been rafted out of Coal and Pocatalico Rivers and other tributaries.

The Charleston Tie-handling Plant

The Charleston tie hoist, on account of the general track layout, is constructed at the top of the bank, with its loading platform and track parallel to the river, having an incline chute or hoist built at an angle to the water. It consists of two endless power-driven chains equipped with spurs, spaced every 6 ft., for engaging the end of the ties for lifting, and of the necessary gunwales at the river and chutes and platforms. The first endless chain works in a specially constructed wooden trough, one end being below the pool stage of the river. This permits of the ties, which are handled with pike poles by men, being placed in the trough for hoisting. The other end delivers the ties to the loading platform to which the trough or chute is connected. The second endless chain engages the ties, carries them first by the tie inspector of the purchaser and thence to the different cars, where laborers with tie picks pull the ties off the chain to the platform, and then load them into the gondola cars over which this loading platform extends.

The cull ties (being specially marked) are allowed to continue to the end of the platform, where they drop onto an incline to the cull-tie yard. The incline trough is built up the bank on a 1 on 2 slope, making an angle of 30° with the loading platform. The special feature of this hoist is the power transmission from one endless chain to the other, which is accomplished by means of three specially designed cog wheels the gears of which are beveled to 10°, making the necessary bend of 30°. The top of the loading platform is 36 ft. above pool stage of Elk River and is 9 ft. above the top of rail of the loading track. This platform is 9 ft. wide and 210 ft. long, permitting of the placing of five cars at one time for loading. The average daily capacity of the hoist is about nine cars; therefore, empties are placed back of the platform and the loads are dropped below, permitting the empty cars to be spotted for loading.

This plant is operated by a 20-hp. four-cycle gas engine at the end of the loading platform. The engine is belt-connected to the main driving shaft, from which the power is transmitted by means of gearing to the endless chain on the platform, from which the beveled gears transmit the power to the chain on the incline. A clutch is provided at the engine for throwing the power on or off. Sprocket wheels are placed on shafts at either end of the platform and incline, also on the intermediate bents below the hoist for supporting the chains on their return movement.

The gas engine was purchased to replace a wornout steam engine and at first considerable trouble was experienced in changing the gearing to suit the increased speed of the gas engine. The difficulties encountered were the slipping of the belt due to the dead load on the start and the stopping of the engine after the hoist was put in operation. This was overcome successfully by the proper gearing of the cog wheels to allow the engine to operate under load at full speed of about 300 r.p.m. The chain moves at a speed under load of 96 ft. per min. The spurs being 6 ft. apart, permit of a maximum possible capacity of 8 ties per min., or 48 ties per hr., giving a daily loading capacity of 4800 ties per 10-hr. working day.

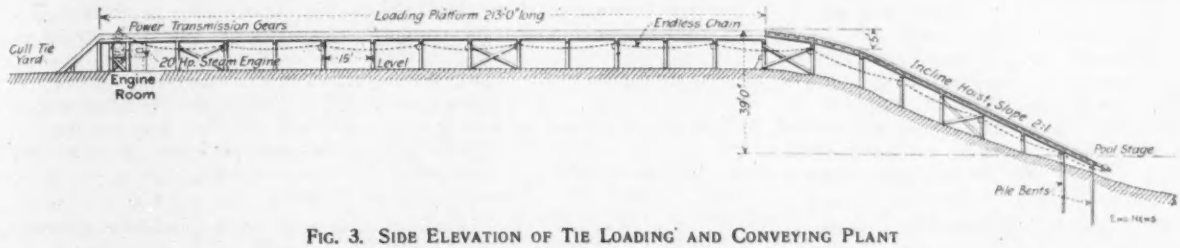

Fig. 3. Side Elevation of Tie Loading and Conveying Plant

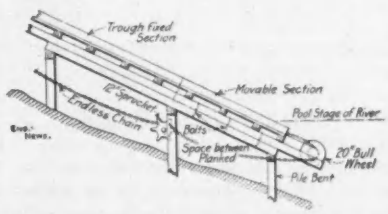

Fig. 4. Detail of River End of Incline for Tie Conveyor (with Movable End Section)

The Brosia Tie-handling Plant

In the location of the tie hoist at Brosia, the first feature to be considered was to find a point on the river where there would be a good pool stage with very little current, which would give a considerable advantage in assembling the rafts and the floating of the ties to the chain of the hoist. The main line at this point is parallel to the river and is only distant about 600 ft. from the top of the bank, therefore loading tracks had to be constructed at right angles to the bank. This gave the advantage of getting two loading tracks (one on either side of the platform), and also the construction of the hoist on a straight line with no bends, thereby having only one endless chain. A sufficient number of cars for the daily capacity (estimated at 10 cars) can be placed for loading by the local freight train, no yard crew being available. The track layout, as shown in Fig. 1, consists of two loading tracks (19 ft. 6 in. on centers), one on either side of the loading platform. The platform is 213 ft. long, permitting of the placing of five cars on each track, (thus giving the total daily capacity of 10 cars. The crossover ahead of the platform permits of the cars being pulled and placed so that the engine can run around them for placing them in the train headed in either direction.

The hoist or conveyor is built straight and is turned at a slight angle down stream in order to lessen the trouble of the trough catching and holding drift during high water. This construction of one endless chain not only eliminated the bevel gears, but lessened materially the power required for operation. The hoist is operated by a 20-hp. single-cylinder steam engine, with flywheel directly connected by means of gear wheels to the end sprocket which propels the hoisting chain. The chain is given considerable slack, which permits of the engine readily starting.

The cross-section, Fig. 2, shows the construction of the loading platform. The trough for the chain to transport the ties is in the center; the 3x3-in. white-oak strips on either side readily hold the ties on the chain and easily permit of them being removed by the use of tie picks to the platform for loading. The platform slopes from the center toward the sides to facilitate the loading, and is made as narrow as consistent to permit of easy handling of the ties from the chain to the cars. The platform is 10 ft. above the rail of the loading track.

The elevation, Fig. 3, shows the general construction of the hoist. A vertical

curve at the top of the incline is provided instead of a knuckle, making an easier travel for the endless chain. The platform is supported by bents spaced 15 ft., each one cross-braced laterally and three pairs of bents braced longitudinally to give sufficient stability. The bents carrying the trough on the incline are spaced 12 ft. on centers and have the same bracing. The two lower bents are of piling, thereby preventing them from being torn away by drift and also giving an anchor for the gunwales. The details of the trough on the incline are shown in Fig. 2. The caps, stringers, etc., of the platform and incline are drift-bolted together.

The engine house is under one end of the platform. The engine and gears are supported on a well braced timber frame constructed of 10x10-in. white oak, the timbers being mortised and drift-bolted together. The 12-in. sprocket wheels, with 3-in. shafts, are supported on every other bent under the trough for carrying the return side of the chain. The boiler is located at one side of the hoist and does the double duty of furnishing steam for the hoist and a pumping station.

The chain is of the ordinary link and pin construction, consisting of 8-in. links with 5½-in. pins provided with 3-in. pipe filler or roller bearings. The 3-in. spurs for engaging the ends of the ties (for lifting them) are spaced 6 ft. apart and attached to the links on each side of the chain. In the trough is provided an inverted 60-lb. rail on which the rollers of the chain travel. A 1½-in. space is left on each side of the rail, allowing the sand and mud to free itself from the chain. This lessened considerably the wear on the chain, as compared with a wooden bearing strip. The wooden bearings were found to soon get filled with grit, and also had to be renewed quite often.

At the lower end of the incline is provided what is termed a bull wheel, a high-flanged wheel 20 in. diameter, which guides the chain on its return movement. As shown in Fig. 4, the lower section of the incline trough is detachable in order to permit of the removal of the bull wheel and chain from the water when the hoist is not in operation; also to permit of removing any drift, etc., which the bull wheel may catch. Extra stringers on either side are fixed to the two pile bents, to which the stringers of this lower section of the trough are clamped and securely bolted. The lower end between the bents is boarded up to prevent the ties when fed to the hoist from being carried under by a jam.

The Brosia hoist is operated by the pumper who is located at the water station combined with the hoist. The hoists are owned and operated by the railway company. The shipper pays 2c. for each tie taken over the hoist. The crew necessary for operation consist of the engineman, foreman and eight laborers.

Progress of Gas Power in 1911*

By Robert H. Fernald†

Increase in the maximum size of internal-combustion engines and an enormous advance in the use of heavy oil engines of the Diesel type are the most important advances made in 1911.

*Annual address of chairman of gas-power section of American Society of Mechanical Engineers.

†Professor of mechanical engineering, Case School of Applied Science, Cleveland, Ohio.

Large Gas-engine Units

The development of large gas-engine units has gone steadily forward for the past decade. The first engine of this class was that exhibited by the John Cockerill Co. at the Paris Exposition in 1900. This was an engine of 600-hp. rating. At the present time 1500 hp. in each cylinder of the four-stroke cycle type and 2000 hp. in each cylinder of the two-stroke cycle engine are reported as one of the exhibits at the Brussels Exposition of 1911. This means units of 8000 hp. of the twin-tandem double-acting type.

It is understood that at least one company is prepared to install gas-engine plants of large power capacity at a cost not exceeding, and in some instances less, than that of the corresponding steam-turbine installations.

Advance in the Development and Application of the Diesel Engine

Although the steam turbine has superseded the reciprocating steam engine for electrical development in central-station work, and will probably hold the field for some time to come, it is interesting to note that the Diesel engine, owing to its great success in small station service, is looked upon seriously as a possible rival to the steam turbine within a short time. In a paper recently presented before the Municipal Electrical Association at Brighton, England, the relative cost of a 10,000-kw. installation for steam turbines, gas producers and engines, and Diesel engines, was discussed at length. The author's proposition was to use seven sets each of 1450-kw. capacity. His figures of operating expense, etc., are decidedly in favor of the Diesel engine installation. Attention was also called to the very economical use of these engines as a substitute for substation converting machinery. Such stations are already putting in their appearance in London.

In this connection it is interesting to note the development in point of size of the Diesel engine. Engines of a few hundred horsepower have become common in European practice. In Swiss electric stations Diesel engine units of 2000 hp. are now in use, and one writer on the subject states that the development of the large sized Diesel engine has been so successful that it will not be long before 1000 hp. developed in one cylinder will be thought nothing extraordinary. One company of world-wide reputation is at present considering more than 2000 hp. in the single cylinder of Diesel engines. It is stated that engines of this type with four cylinders developing 1000 hp. each can be made as light as the corresponding triple-expansion steam engine.

The weight of such engines compares favorably with that of the corresponding turbines and boilers. It is understood that a 1000-hp. installation of this type weighed only 187 lb. per horsepower as compared with 180 lb. for a steam turbine and boiler installation.

The crude-oil engine is now definitely under consideration for all types of marine craft. For small vessels the advantage lies in the safety afforded by the use of crude oil as compared with the lighter oils. The crude-oil engine is being used by many of the principal navies of the world for submarine boats, and designs are already under way for comparatively large engines for torpedo boats and other similar craft.

A few months since, the "Vulcanus," a vessel of 1900 tons displacement, 196 ft. long, equipped with six-cylinder four-cycle single-acting reversible Diesel engines, was put in regular service between Holland and Borneo. This engine is about 500-b.hp. capacity at 180 r.p.m. The fuel is a crude oil from Borneo, and the quoted guarantees are 0.42 lb. per b.hp. hour at full speed; 0.44 lb. at three-quarters speed, and 0.5 lb. at half speed. In a recent trip the "Vulcanus" covered 3312 miles in 19 days and 3 hours. The average speeds varied from 6.86 knots to 7.80. It is understood that the average consumption for this ship amounts to one ton of fuel oil per 100 knots.

This month, two vessels, nearly 400 ft. long, of 7000-tons capacity, each fitted with Diesel engines of 2500-hp. rating, and with two auxiliary Diesel engines aggregating 500 hp., will be tried out in Euro-

pean waters. The British admiralty proposes to try, side by side in a twin-screw cruiser, a steam engine and a Diesel engine of 6000-hp. rating.

Another destroyer recently ordered by the British admiralty, according to current reports, will have on each shaft a steam turbine and a Diesel engine. The plan is to operate the turbines when high speeds are required, but under cruising conditions, when the speeds are low, owing to the poor economy of the steam turbines, the Diesel engines will be used.

With the introduction of these engines the discomforts of the stoke-hole will be greatly reduced, and the amount of labor required will be less than under present marine conditions and the character of labor much improved. The fuel needed approximates a third of that needed for the steam engine, thus greatly increasing the radius of action if the same weight of fuel be carried. Boilers can be done away with and their space utilized for carrying cargo. It is reported for a freight vessel of 2700 tons that a saving of over $19 per day was made by using oil at approximately $11 per ton, instead of coal at about $3 per ton.

Tar as Fuel for Diesel Engines

Tar oil has become more or less common as a fuel in Diesel engines for 600 or 800 hp., and it is understood that it is used in at least one engine of 4000 hp. Recent experiments indicate that both thin gas-retort tar and thick coke-oven tar can be used in a similar manner by injecting into the cylinder a small percentage of light oil to assist in igniting the tar. It is claimed that a wide range of tars can be used in this manner without producing smoke or appreciable residue. In tests at the Körting works, about 2% of the ignition oil was used at full load and about 13% at half load. Reports indicate that an order has been placed for a 600-hp. Diesel engine to operate on raw tar.

Internal-combustion Engine Locomotives

Locomotives using internal-combustion engines and operating on the standard-gage track have recently been put into service. The range of fuel for these engines covers gasoline, benzol, alcohol, and petroleum. The Prussian State Railways are reported to be operating a 1000-hp. locomotive using a Diesel engine as motive power.

Gas Turbines

Results are soon to be expected from the more recent investigations and tests relating to gas turbines. It is believed that some of the types are based on correct principles, and that after a rotary air compressor of satisfactory design has been secured, rapid progress in the development of this prime mover may be expected.

Mr. Humphrey says:

With the compression pressure of 11 atmospheres absolute the theoretical thermal efficiency of the cycle is 52.5%, whereas that of the Otto cycle is only 40% when all corrections for varying specific heats are allowed for. With very moderate compression, under 50 lb., an actual thermal efficiency of 23% has been obtained on a four-cycle Humphrey pump. This corresponds to 0.95 lb. of anthracite per hydraulic horsepower-hour, and was obtained on a lift of only 35 ft.

Surface Combustion

By what he terms "surface combustion," Prof. Bone reports for gas-fired boilers evaporations of 21.6 lb. per sq.ft. of heating surface, and an efficiency of heat transmission of 94%. The heat balance of a test reported by him shows:

Gas burned per hour (at 32 F. and 14.7 lb.)	997 cu.ft.
Net calorific value of gas	562 B.t.u.
Total heat supply to boiler per hour	559,800 B.t.u.
Temperature of feed water	42 R.
Pressure of steam	100 lb.
Water evaporated per hour	450.3 lb.
Water evaporated from and at 212 F.	550 lb.
Heat transmitted to water 450.3 × 1172 =	527,800 B.t.u.
Heat ratio 527,800 ÷ 559,800	943

In the reports of the surprising results of these investigations, attention is called to the fact that the combustion was perfect, as was shown by analysis. An efficiency of 94% was obtained. Deducting 4% for the power required for supplying air pressure still leaves 90%.

Prof. Bone says:

The new boilers could be set up in brick work and require no elaborate flues or chimneys. They are liable to no strains as they are short. With some sacrifice of efficiency the evaporation could be raised to 30 lb. per sq.ft. The steam was raised quickly (steam at 100 lb. pressure obtained in 20 minutes from cold start) and tubes could be grouped and cut out separately so as to vary the fuel consumption to suit the fluctuations of load.

Producer Gas from Low-grade Fuels

Progress is steadily being made in the utilization of lignite, peat, and high-ash coal in producer-gas work. The investigations of the Canadian government show that peat can be prepared for fuel purposes at a cost averaging from 30% to 40% of that of an equivalent B.t.u. value in anthracite in Canada. As the foundation of a method that may result in extensive use of high-ash fuels without prohibitive cost of operation, attention is directed to the present producer-gas investigations of the United States Bureau of Mines, resulting in the successful fusing of the ash and the use of water-cooled producer linings.

Small Producers for Bituminous Coal

Reports are persistently before us indicating the successful development of gas producers of small power to operate on bituminous coal, coke breeze, anthracite screenings, "front-end cinders," etc. Such plants are in great demand, but it is doubtful whether the development and application have been as great as the advertising these plants receive. It is interesting to record, however, that a company, manufacturing anthracite gas producers and gas engines, which expressed in 1904 its firm conviction that the Government tests with bituminous coal in producers would fail utterly, recently put itself on record as recommending the use of its own engines with small bituminous producers manufactured by another company.

Crude-oil Gas Producers

The development of the crude-oil gas producer, for which there is great demand in oil regions remote from the coal field, has been exceedingly slow, but it is believed that very definite progress has recently been made along this line. The most recent notes on this subject relate to the Grine oil producer. In this type the steam spray is used for atomizing the oil, which is introduced into the upper part of the generator, where partial combustion takes place. The down-draft principle is then applied and the hydrocarbon broken up and the tap fixed by passing through a bed of incandescent coke. Mr. Grine reports that a power plant using one of these producers has been in operation a year in California. With crude oil as fuel, costing 85c. per bbl., or 2.3c. per gal., the plant is reported to develop the same amount of power per gallon of crude oil as is ordinarily developed by the standard internal-combustion engine operating on distillate at 7c. per gal.

The opportunity for investigation in the gas-power field is at present unlimited, as is evidenced by the fact that nearly a hundred important gas-power problems are at present on file at the U. S. Bureau of Mines under the head of "Proposed Investigations."

Bids for Standing Timber in the Tahoe National Forest in California are being advertised for by the Department of Agriculture. About 73 million feet of saw timber is offered for sale, the purchasers to have ten years in which to remove the timber. The price to be paid for the timber will be adjusted at the end of the first five-year period in accordance with the market price of lumber during the year preceding that time. About 20 miles of railway will have to be constructed to reach and remove the timber. In the work of removal the contract requires the purchasers to use proper care to conserve the small growth so as to insure the renewal of the forest. It is estimated that there are over 500 billion feet board measure of standing timber in the National Forest, which is mature and ready to be cut. Over 830 million feet were sold by the Forest Service during the year ending on June 30, 1911.

Freighthouse-door Indicators have been installed at one of the local freight stations of the Prussian State Railways in Berlin, Germany. Their object is to inform arriving teamsters as to which doors are vacant. The indicator consists of a frame set on a 20-ft pole, carrying a number of lamp-boxes, one for each door. A 50-cp. electric lamp shows red when the corresponding door is vacant. Whether the lamp switching is done manually or automatically is not stated. (Zeitschr. d. Ver. deutsch. Ing, Dec 16, 1911)

Comparative Tests of Cement Gun Concrete and Hand Applied Concrete

A series of tests of very interesting character was made recently by the engineering firm of Westinghouse, Church, Kerr & Co., for the European Cement-Gun Co., 30 Church St., New York City, with a view to determining whether concrete-surface coatings applied by the new air-blast device known as the "Cement Gun" are equal to or superior to hand-applied coatings.

For these tests, sample coatings were made by both hand and cement-gun processes, and tests were carried out for tensile strength, crushing strength, surface permeability, absorption, percentage of voids or porosity, and adhesion to other materials, such as brick, stone and iron.

Portions of the report rendered by the engineers were published in the December issue of *The Mason Builder*,* where the full tables of results are given. The following extracts indicate the general tenor of the report.

It was found that all the tests showed distinct superiority of the cement-gun concrete to the hand-applied concrete. In the case of tensile and compressive strength, an advantage of 20% to several hundred per cent. was shown. Permeability and absorption showed values for the machine coatings fully one-third less than for hand-applied coatings. The cement-gun product also was found to be more dense. In the adhesion tests, while the figures obtained were greatly variable, the hand-applied cement was, nevertheless, distinctly inferior.

Summaries of the tables of results are given below, as representing fairly the general nature of the results. In all cases the tests included mixtures with different sands, but we have generally selected those made with standard Ottawa sand for the purposes of this comparison. Cement-sand mixtures ranging from 1:3 up to 1:7 and even leaner were tried. Some of the tests included samples made with lime admixture. Our extracts generally represent the results for 1:3, 1:4 and 1:5 cement-sand mixture. But it is important to note that the cement-gun coatings were really richer than the original proportions of mixture, as stated in a note at the foot of the tables.

While the conditions of experimentation are not fully stated, it would appear from the tables that the cement-gun concrete has normally a tensile strength nearly double that of similar hand-applied coating, and a compressive strength ranging possibly 50% higher than that of the hand-applied coating. The permeability results given in our extract, ranging from a ratio of 0.19 to 0.70, suggest that the cement-gun coating gives normally quite distinctly more resistance to the entrance of water than hand-applied concrete. The absorption and porosity tests clearly indicate greater density of the coating applied by the machine.

The original report (but not the *Mason Builder* reprint) states that both kinds of coatings were made with special care so as to secure the best test specimens possible. The report contains the following conclusions:

In all the tests made, the product of the cement gun showed superior to good hand-made product of the same kind. The degree of superiority varied between wide limits.

In tensile strength the gun work excelled hand work in every case by amounts ranging from 20% to 260%.

In compressive strength the excellence of the gun work was even more marked, ranging from 20% to 720% better than handwork.

In the matter of surface permeability the gun work absorbed from $\frac{1}{10}$ down to $\frac{1}{30}$ as much water per hour per unit of area as the similar hand-made surfaces.

As regards absorption of water, the hand-made mortars took up from 1.4 to 5.3 times as much as the gun-made mortars.

The percentage of voids of the gun-made product ranged from 52% to 75% of that of the hand-made product.

The adhesion of the gun-applied mortars was, on the average, 27% better than that of the hand work.

The table summaries here given do not contain the results of the adhesion tests. The mortars used in this test were of 1:4 mixture. A number of the hand-made specimens broke before testing, and the comparison is thereby vitiated. The average results of those specimens which did not break before reaching the time of test were, for gun-made concrete 465 lb. per sq.in., for hand-made concrete 365 lb. per sq.in., giving a ratio of gun to hand concrete 1.27.

The above notes and our extracts from the tables include some data not contained in the *Mason Builder* reprint, but supplied by Mr. Cloyd M. Chapman, the engineer who conducted the tests. For closer study of the subject, the full tables should be consulted, in the source mentioned.

*House organ of Chas. Warner Co., of Wilmington, Del.; 103 Park Ave., New York, N. Y.

TENSILE TESTS

(with standard Ottawa sand)

TENSILE STRENGTH, LB. PER SQ. IN.

Mix.	7 days Hand	7 days Gun	7 days Ratio Gun to Hand	28 days Hand	28 days Gun	28 days Ratio Gun to Hand
1:3	214	463	2.20	290	661	2.30
1:4	164	346	2.1)	222	601	2.70
1:5	108	530	4.90	148	540	3.60

CRUSHING TESTS

2-in. Cubes. Tested at age of 28 days
(with standard Ottawa sand)

CRUSHING STRENGTH, LB. PER SQ. IN.

Mix.	Hand	Gun	Ratio Gun to Hand
1:3	2406	2936	1.2
1:4	1770	3459	2.0
1:5	1740	2949	1.7

PERMEABILITY TESTS

At age of 5 weeks
(with fine beach sand)

WATER ABSORBED BY A SURFACE OF 0.02 SQ. M., C. C. PER HR.

Mix.	Hand	Gun	Ratio Gun to Hand
1:3	43.5	8.2	0.19
1:4	21.9	11.2	0.51
1:5	50.3	35.0	0.70

ABSORPTION TESTS

At age of 28 days
(with standard Ottawa sand)

PERCENTAGE ABSORPTION

Mix.	Hand	Gun	Ratio Gun to Hand
1:3	3.5%	0.66%	0.19
1:4	4:4%	1.11%	0.25
1:5	4.6%	1.04%	0.23

POROSITY TESTS

At age of 90 days, using specimens from absorption tests
(with Cow Bay sand)

PERCENT VOIDS

Mix.	Hand	Gun	Ratio Gun to Hand
1:3	19.2%	12.7%	0.66
1:4	22:6%	15.1%	0.67

Note—The figures given in the column "Mix" refer to the proportions or materials supplied. The cement-gun process caused enough scatter of sand to make the applied coating considerably richer. It is estimated by the engineer of test that the mix marked 1:4 gave, when used in the "gun," a coating of about 1:3 proportion. If this fact is taken into account, the comparison would come out somewhat less disadvantageous for the hand-applied coatings.

Notes on an Automatic Telephone System Recently Built in San Francisco*

BY S. G. MCMEEN†

The design of the telephone system here described was begun in September, 1906, five months after the earthquake and ensuing fire. The designs were general in the sense that they were based on a development study which attempted to forecast growth up to 1925; they were particular in that they called for the construction and assembly of buildings, lines and apparatus. Construction work was begun in 1907 and completed in December, 1910. The system serves the cities of San Francisco, Oakland and Berkeley, with a total population of about 609,000 of which 417,000 are in San Francisco, and it comprises (1) a wire plant of submarine, underground and aërial cables, connecting (2) ten groups of automatic switching apparatus housed in ten buildings, five of which are in San Francisco, four in Oakland and one in Berkeley.

The nearness of the sea and the prevalence of fogs during the summer control the use of unprotected iron and steel in lines and supports and affect the insulation of cable terminals and apparatus. Though the season of rainfall is short, eight or nine months of the year being dry, enough rain falls during the short rainy season to make moisture problems more serious than in most parts of the United States. Snow and sleet and freezing being practically unknown, the requirements of strength in overhead wires are not severe. Absence of freezing also simplifies the use of iron pipes as lateral underground conduits for cables, since water trapping is not objectionable un-

*Brief abstract of a paper printed in the October Journal of the Western Society of Engineers.

†Bay Cities Home Telephone Co., San Francisco, Cal.

less the water freezes. The climate permits outdoor work to be done with economy during the entire year.

Certain features of the work were controlled by franchise and a contract. The franchise stipulated that $2,000,000 should be spent during the first year, $3,000,000 during the first two years and $4,000,000 during the first three years.

The cables are largely carried in underground conduits, with some on poles, buildings, fences and walls. Main conduits are of vitrified terra cotta or bituminized wood fiber. Laterals are of these materials and also of iron pipe. The number of ducts in a conduit varies from four to 80, always with four ducts in each horizontal layer. The assembled ducts are inclosed in concrete, varying in thickness from 2 to 3 in. on top, bottom and sides. The earth in San Francisco is a well washed sand, so that if a sewer breaks, heavy rainfall may loosen and carry away great quantities of filling. If the hole grows large enough to undermine a water main, that may open up and assist the excavation. A conduit not well protected by concrete will fall apart after the sand around it is washed away by such an accident. The conduit work described has experienced such accidents, and in all cases has maintained itself as a beam across the gap. The San Francisco portion of the system contains 2,055,000 ft. of duct, 3½ in. in diameter, laid in some 240,000 ft. of trench and entering 1089 manholes. These are all of concrete, molded in wooden forms.

Clear conduit space was found to be scarce, and records of existing pipes and conduits were scarcer. In San Francisco in 1906 there were no records because fire had destroyed them; it was found as convenient to use the streets themselves as records, and no place was found where one more conduit could not be laid—at some depth. In one instance it was necessary to lay a section 20 ft. below the street surface. At this point, four street-car tracks crossed, and there was a great deal of pipe congestion. As there was no convenient way of opening up a trench, the work was tunneled. After the conduit had been laid and some sand packed around it, the tunnel was tapped from above and filled with sand by means of water. Two years later the street surfaces were still level.

Subscribers' lines are carried in lead-covered cables through the conduit system. These cables pass to terminals in buildings, on back walls and on poles. The latter are run along the streets or on private property; the system operates under regulations which permit of pole lines, except in a small downtown area. The poles on private property are only distributing points connected with the main conduit by a lateral cable carried underground through iron pipe.

It is attempted to provide lines in which the electrical losses are limited enough to enable any subscriber to talk over long-distance trunk lines to another in a distant community similarly equipped. It is customary to say that entirely satisfactory local telephoning is done if a subscriber may talk to another with a quality equal to that through ten or twelve miles of standard cable (No. 19 B. & S.-gage copper, with an electrostatic capacity of 0.06 microfarads per mile). Long-distance transmission is practical for the general public if it is as good as that through 30 miles of such cable. Speech is possible through much more than 30 miles, but it is comfortable for normal persons at that value. A long line can be treated with improving devices or heavier wire used so that the intrinsic quality is higher than the standard cable. For short local lines it is not necessary to use cable as good as the standard. In the San Francisco system the two subscribers having the longest lines to central offices joined by the longest trunk lines can talk as comfortably as if connected directly through about nine miles of the standard cable. Subscribers having sharter lines joined to nearer central offices will have even better connections.

The switching centers of the peninsular and mainland portions of the system are actually 8½ miles apart. A little over 3½ miles is in submarine cable and a little less than five miles is in underground cable; the intrinsic quality of the submarine portion is about equal to the standard cable described, but the land portion is much higher. The result of joining the three sections is to bring the offices within 6½ miles of standard cable.

The cables are formed of paper-insulated copper wires twisted in pairs and covered by a lead sheath. Subscribers' lines are generally of No. 22 B. & S. gage; trunk lines are of Nos. 20, 19 and 13, the latter leading to the submarine cables. Outside distributing wires from wall and fence terminals are generally of No. 18. Where terminals are located inside buildings, No. 19 wire leads to the instrument. The cables must be terminated in a moisture-proof device, as the conductors have paper insulation.

At the time this system was designed, the best two ways of terminating cables were to end them (1) in a separate wooden box whose sides contained binding screws and whose inner space could be filled with compound, and (2) in a cast-iron chamber with a porcelain front, the latter carrying the binding screws and the conductors and cable being sealed in compound within the chamber. The wood-box terminal loses its insulation during the rainy season, and the cast-iron terminal is costly. A new terminal has been developed consisting of two slabs of porcelain carrying the binding screws, the slabs forming a tubular box for containing the sealing compound around the cable end and conductors.

All the central office buildings are of fireproof construction, and range in capacity from 10,000 to 50,000 lines. They are equipped with standpipes, sand pails, and acid and carbon-tetrachloride fire extinguishers. The switching equipment is of the automatic type, that in the San Francisco offices being a two-wire type and that in the main-land offices a three-wire. The former is later and preferable, having no ground contact in setting up and taking down connections.

Shortly after the completion of the general design a local ordinance made it inadvisable to sell business and professional services at flat rates, and required the design of a system of recording conversations. The meters evolved count up to 10,000 and repeat, and only answered calls are recorded. A call which finds a busy line or an unattended telephone does not operate the meter.

A line can be in trouble in two ways: (1) To cause current to flow through, even though the telephone is unused, or (2) when current will not flow. In the one case, we have a permanent signal, as it is called, and no one can get that line. In the second case, the party cannot answer and the call does not register on the meter. We take no responsibility for getting of wrong numbers, but that question has never brought any grief to us.

The power plants are of the usual type, with several sources of primary power available. A single battery is used in the office, and the discharge potential is kept uniform by switching in cells.

Private-branch exchange boards are of three kinds: (1) Those with switchboards and operators; (2) those having intercommunicating key sets, by which each user becomes the operator; and (3) those having true automatic switches on the subscriber's premises. The first two types are similar to those used for manual central-office boards; however, the operator may know by lamp signals when a called subscriber answers, so that it is not necessary to listen. The complete automatic private-branch exchange equipment is found useful in apartment houses, where there is not enough traffic to warrant keeping an operator on duty.

The toll switchboard is like any other. The automatic apparatus brings the call to the long-distance board and there it is handled broadly the same as in a toll board serving local manual boards.

The capacity of the machinery to do the switching is at the rate of 16 calls per subscriber per day—a figure which will not soon be reached in a measured service system. The heaviest trial of the capacity was given when San Francisco learned that it had succeeded in getting the 1915 International Exposition. The signal of success was a bomb; everybody rushed to the window and then rushed to the telephone. So far as we know, all calls went through.

Tensile Tests of Lap Joints of Reinforcing Rods for Concrete Work*

By Wm. Artingstall†

In connection with the method for carrying on the tunnel work at Washington St. [by the successive concreting of superimposed drifts for each wall] it was necessary to use splices in the vertical reinforcing rods at the various drift levels. As it was not deemed prudent to rely entirely on the bonding strength of the concrete to transmit the stress from one rod to another, tests were made on 1-in. twisted-steel reinforcing rods spliced with clamps.

These test splices consisted of one or more simple "U" clamps securing the overlapped ends of the rods; the whole then being placed under tension, load was applied at a rate of 1000 lb. per minute. As the keys left in the [top] concrete face of each drift allowed a minimum of 8 in. overlap, this length of splice was used in the testing of the effect of: (1) A single clamp; (2) two clamps fastened on opposite sides; (3) three clamps—two applied from one side and one from the opposite side.

The results showed that the second type was in general the best to use in construction work. This type, when the clamp was tightened enough to slightly bend the plate, showed no movement up to a resistance of 6400 lb., at which load there was a slip of ⅛ in. When put under further load there was no movement until the stress reached 13,690 lb., when there was a sudden slip of $\frac{3}{16}$ in. in the strap of one of the clamps and ⅛-in. slip of the rods. The rods then began to pull apart at this or a lower stress.

The single clamp allowed the bars to move practically as soon as any stress was applied, and showed a slip of ⅛ in. at 4000 lb. stress, increasing to ¼-in. slip at 5600 pounds.

With three clamps, there was a slip of ⅛ in. on the bars with a stress of 6760 lb. At 10,730 lb., one of the straps started to move, another started at 11,690 lb., and the third started at 18,330 lb. The total slip at this time was ½ in. At 25,580 lb. there was a sudden slip of the bars and one clamp became entirely loose, so that no further load was applied.

The designs were based on a unit stress of 16,000 lb. per sq.in. in the steel, and the tests showed that the clamps were good for about 7000 lb. up to the first slip, which was always a sudden one of ⅛ in. Assuming that this resistance would be increased when the rods were embedded in concrete, it was decided to use a splice of the second type, and rely on the bonding stress of the concrete to supply the deficiency between the resistance of the clamp and the stress in the steel. In the various drift levels the key was about 12 in. in depth, which assumed a minimum of 8 in. overlap, as previously stated. This made it a fairly easy matter to apply the clamps in position.

The writer believes that the resistance of the splice would have been greatly increased by the use of a plate with corrugations approximating the twist in the bars, which would have given a greater bearing area between the plate and the bars.

*From a paper on "The History and Reconstruction of the Chicago River Tunnels" in the November number of the "Journal" of the Western Society of Engineers, Chicago. The work on the Washington St. tunnel, mentioned in this article, was described in our issue of July 21, 1910.

†Division engineer, board of supervising engineers, Borland Block, Chicago.

Letters to the Editor

Why Concrete Buildings Fail; A Contractor's View

Sir—In regard to the letters headed, "Why Reinforced-Concrete Buildings Fail," in your issue of Dec. 21, 1911, p. 745, I should like to suggest the following:

As to the necessity of inspection of reinforced-concrete work, Mr. Kahn's article speaks of this from the engineer's point of view, and assumes that the safety of the building depends on the engineering inspection.

While engineering inspection of an intelligent sort is desirable and is of very great use in the building of reinforced concrete, it must be understood that no one man can inspect an incompetent gang of reinforced concrete builders into doing a first-class job. Probably a single inspector for each operation would have difficulty in doing this unless each inspector had full authority to move the men. In most cases construction work is bad not through intent, but through inability of the builder to handle it intelligently.

Our belief is that much bad reinforced-concrete work comes through the belief that an engineer can inspect an incompetent building outfit into building a first-class job, the owner's belief being that if the builder is prevented from slighting the work, and is required to make it good, that good work will result. The younger and less experienced engineers are afraid to tell an owner that no man is able to inspect an incompetent outfit into building well, for fear that such a statement would cause the owner to think them incompetent, and also through a queer, hazy idea that most any building outfit really understands how to build well if they care to do so.

Besides Mr. Kahn's very reasonable explanation of the reason that failures so frequently occur during the building of roofs, there is another reason which has seemed obvious to the writer, namely, that the average small contracting outfit does not have an accurate enough cost-keeping system to show them, from time to time as the work progresses, just what the work is costing and how near it is coming to the estimate. As the work reaches a close, however, the simple total of the ledger shows them all too frequently that the work is costing more than they are getting for it, with the result that at the end of the job there is a frantic effort to make economies of every sort, the most obvious economies being to use less cement and to hasten the drawing of forms, with the result that over and over again the building's collapse comes from some pure carelessness which could be readily avoided.

With the common failure to understand very much about concrete costs, and with the inability of the new and unorganized concerns to make reasonable costs if they knew them, the wonder is that there is so little failure in reinforced concrete. The average owner, and it would sometimes seem as if the average engineer, fails to realize the very great danger which there is from careless handling of this class of work. There is no other structural material entering into building and engineering work which is made on the job. Steel, timber, brick, all come on the job completed, and the problem there is only the setting of the material, and the fastening of it together. In concrete, however, there are several operations before the placing of the material in its final position.

Each operation requires knowledge of the material, and in each there is the chance for mistakes in workmanship, and the use of bad material. There is probably no other kind of building which requires more specialized knowledge or needs more conscience in its handling.

M. C. Tuttle,
Secretary Aberthaw Construction Co.
Boston, Mass., Dec. 26, 1911.

The Causes of Rail Corrugation

Sir: I have read with much interest the article on rail corrugations in your issue of Nov. 30, and the accompanying editorial comment, but as some of the statements made do not agree with observed facts, I shall be obliged if you will grant me the privilege of making a few comments.

Taking first Mr. Mohler's curt dismissal of the theories already advanced by other investigators it would seem to me that they are entitled to just a little more consideration. The "proof" advanced that none of the other theories explain the true cause of corrugation seems to the writer to be entirely inadequate. While it is obvious that the causes listed in the second paragraph of the article are present in practically all forms of traction it does not necessarily follow that they are just "as potent in the production of corrugation under one form of traction as in another."

It is quite conceivable that causes which might produce corrugations under one form of traction would not have the same effect under that of another. It is further conceivable, and in my opinion demonstrable, that certain causes will produce corrugations in some parts of a track and not in similar parts of the same track under the same forms of traction, due to certain conditions which cannot be overlooked. In an article on this subject which appeared in the *Electric Railway Journal* of Sept. 30, 1911, I endeavored to point out the difference in conditions which would account for this phenomenon.

Considering next Mr. Mohler's explanation of the occurrences of corrugation I must confess after a careful reading of his article that I have been unable to find any specific statement of what he considers actually produces the indentations or corrugations in the rail, but assume that he wishes to convey the impression that the metal is worn away or abraded by the slipping of the wheels, this slipping being occasioned by improper coning of wheels, braking, guard rails, etc.

Before this explanation can be accepted we must accept as a fact that slipping actually does take place in accordance with the diagram and theory of the author, although he himself states them only as probabilities, likelihoods, tendencies, etc. Further it must be admitted that wherever corrugations occur the slipping must be non-uniform, since according to the author where the slipping is uniform the rail will wear perfectly smooth.

Although it is not clear just why the slipping should be non-uniform on curves of long radius where the amount of slipping is small, and perfectly uniform on curves of short radius where the amount of slipping is relatively great, let us assume this is so for the sake of argument. Having granted this, if Mr. Mohler's explanation of corrugation is correct it should not only account for corrugations where they appcr but also for their non-appearance under identical conditions of curvature, rolling stock, brake rigging, guard rail, etc. But does it?

Considering now only electric traction, it is agreed by all who have made a study of the problem: (1) That corrugation rarely occurs on interurban track except at or near stations: (2) that T-rail in paved streets is not much affected, but under certain conditions does corrugate rapidly; (3) that high girder rails in paved streets are most affected: (4) that corrugations are most often found on curves of long radius where the rail is laid in pavement, but rarely if ever on curves of the same radius where rails are not imbedded, the type of rail being the same in both cases; (5) that the length of the corrugation varies from a fraction of an inch to several feet and this length changes with the speed of the cars; (6) that corrugations rarely if ever appear on short radius curves although special guard-rail sections are used.

Let us now apply the explanation to these cases. It is stated by the author that corrugations should be slow in developing on T-rail and on straight-lipped rail, although it is not apparent why the slipping should not occur on these rails on curves and where the brakes are applied in just the same way as on grooved rails. The fact is, however, that under certain conditions corrugations appear very rapidly on T-rail on a uniform solid foundation as may be verified by reference to the proceedings of the American Electric Railway Association.

It is stated also that the riding of the flange on the lip of girder rails is the reason why they are more susceptible to corrugations, although it is admitted that corrugations appear where the flanges do not touch the lip. Here the author himself appears to doubt his own explanations and reverts to the bad track surface, uneven gage, etc., which he has already proved could not be responsible.

Next the author states that on track without a guard rail and of relatively light curvature, corrugations may not develop at all and that when slipping back occurs it will do so on the inner rail. This implies that the corrugations if any would appear on the inside while in reality the worst cases of corrugations occur on the outside rail of just such curves. It is hardly necessary to state other instances where this explanation does not agree with actual observations.

Attention should be called, however, to Fig. 10, as to which the author states the flat spot was worn in the near rail as a result of wheels riding on their flanges through a shallow groove in the opposite rail. I believe that even all practical men will admit that this flat spot is caused by the blow transmitted through the axle when the wheel passes over the frog. Similar cases may be found on any track on solid foundation where the joints are staggered and not properly maintained, regardless of the section of rail, and this phenomenon has absolutely no bearing on corrugation.

In the opinion of the writer the original assumptions do not follow the law of probability. That a wheel will roll over a crest a fraction of an inch long, and then slide over a depression some inches or even a foot long, or that slipping will always take place so uniformly on sharp curves that the wear is perfectly uniform, cannot be accepted as probable; not to mention the fact that in order to account for the production of corrugation at each end of the same curve it is necessary to assume that the slipping occurs non-uniformly and begins always at the same place.

At the risk of being classed with the "scientists and physicists," in contradistinction to practical men, I shall quote from my own article above referred to in defense of the theories already advanced. [This quotation is printed below.—ED.]

In conclusion it seems to the writer that your editorial on Mr. Mohler's article is hardly in keeping with the usual fairmindedness of ENGINEERING NEWS and that the criticism of Mr. Beaumont's article is unnecessarily severe. That the latter's choice of language was not most appropriate depends perhaps upon the point of view, but it does not alter the fact that his theories are based on experiments and data which are in agreement with those of other investigators (notably P. H. Dudley) as you will see by reference to the file of the ENGINEERING NEWS.

Granting that Mr. Beaumont's deductions and suggestions for preventing corrugations will not be accepted by many, his method of procedure in investigating the subject was not only far more scientific but in the opinion of the writer more "practical" and more in accordance with "common sense" than the article referred to in the editorial.

G. E. PELLISSIER,
Superintendent, Goldschmidt Thermit Co., New York, N. Y., Dec. 5.

From Mr. Pellissier's paper in the *Electric Railway Journal*.

Proceeding on the assumption that whatever explanation of the phenomenon of corrugation is advanced in order to be satisfactory must necessarily account for the facts mentioned above [appearance and nonappearance of corrugation], the writer has evolved a theory which it is believed fulfills these conditions, namely:

(1) That corrugations are directly due to nonuniformity of pressure between the tread of the car wheel and the surface of the rail, and between the flange of the wheel and the side of the rail head, and only occur when the pressure at the point of maximum intensity of

pressure exceeds the elastic limit of steel at that point; (2) that any condition or set of conditions which produced this non-uniformity of pressure will cause corrugations if the maximum intensity of pressure exceeds the elastic limit of the rail material; (3) that comparatively few combinations of circumstances cause the maximum intensity of pressure to exceed the cubical elastic limit of steel; (4) that any conditions which cause the position of a point of maximum intensity of pressure to move away from the approximate center of the rail head to the edge where any particles are not restrained, but free to move in one or more directions, reduces the elastic limit to its lineal value, which is not more than one-third of its cubical value according to good authorities; (5) that the shape of the rail head, wheel tread and wheel flange, and the position of the one relative to the other under traffic, have great influence on the position of maximum intensity of pressure and thus are responsible for most of the corrugations; (6) that by so designing the rail head, wheel tread and wheel flange and so laying the rails that the maximum intensity of pressure will occur near the center of the straight surface of the rail and as far as possible from the corner or edge of the side of the rail, most of the corrugations can be eliminated; (7) that corrugations produced by pressures exceeding the cubical elastic limit of steel (such as might occur with quick braking of heavy fast trains) can be eliminated only by raising the elastic limit of the steel, increasing the area of contact between the wheel and rail or by making the acceleration (positive or negative) so uniform that a uniform cold flowing of the metal will follow.

In support of this theory a few facts regarding the intensity of pressure and its points of application may be of interest. Considering the surface of the rail a horizontal plane and the wheel a right cylinder, the contact between the two would take place along a straight line, neglecting for the moment elasticity. If, however, the surface of the rail is a plane and the wheel is conical, the contact between the two occurs at a point unless the wheel and the rail are free to move until an element of the cone coincides with an element of the plane.

Since, however, in the case of rails laid in pavement it is not possible to obtain this adjustment of wheel and rail, and because we have not only coned wheels, but rails, whose heads are not plane surfaces, we obtain contacts between the two varying from a point to a line, modified by the elasticity of the metal to a spot and an irregular area across the head of the rail. Actual measurements of the area of contact made on various types of rails by placing a pair of standard 20-in. wheels fixed on an axle and then applying a pressure of five tone to each wheel, showed it to vary from less than ¼ to about ¾ sq.in., depending on the type of rail and its position relative to the wheel. Fig. 1 shows roughly the size and location of a contact area. These, of course, are only representative and will be further modified when the car is in motion and when the load and diameter of wheels are varied.

As the wheel load taken is not excessive, 5 tons, while in practice 6 or 7 tons are not uncommon, we can use the above figures for a simple calculation, assuming the intensity of pressure to be uniform over the entire area of contact. In the cases where the area of contact is ¼ sq.in. we have the intensity of pressure of 40,000 lb. per sq.in., which is certainly close to, if it does not exceed the linear elastic limit of ordinary rail steel.

When we consider, however, that the intensity of pressure is not uniform, but varies from nothing at the edge of the contact area to the maximum at the center, and that these figures are materially increased by loading, impact, braking, etc., it is readily seen that the linear elastic limit of steel must often be exceeded. It must not be forgotten, also, that in producing these contact areas new wheels and rails were used; that care was taken to so place them that the maximum area of contact would be developed, and further (most important) that the rails being merely laid on a cast-iron bedplate were free to adjust themselves under pressure. With the rail laid in track or subjected to traffic we find quite a different set of conditions. (1) The rails being held together by the rods or supported by rail braces and imbedded in pavement are not entirely free to adjust themselves under pressure, so that the position of the point of maximum intensity of pressure is determined largely by the shape of the wheel and rail. (2) The track is rarely laid so that the wheels will make contact with the rail at corresponding points along its entire length. (3) On account of defective gage of track and wheels the contacts cannot always take place between tread of wheel and surface of rail, but somewhere along the gage line. (4) Flanges sometimes ride either on the bottom of the groove or on the inside of same. (5) Centrifugal forces tend to make the wheels climb outside the rail going around curves. Other differences could be noted, but the above are the most important. It will readily be seen from Fig. 2 that in all these cases the area of contact must be materialy reduced.

If the rails were free to adjust themselves under pressure, all the other conditions mentioned would be of small moment, as the point of maximum intensity would tend automatically to keep away from the edge of the rail, both on the tread and side of head. When, however, they are not free to adjust themselves, the rail head and wheel tread must be so shaped that under traffic conditions the point of maximum intensity of pressure will not fall at the edge of the rail. This, of course, can be accomplished in many ways; but the simplest way, which naturally presents itself, is to make the tread of the rail approach the arc of a circle instead of a plane, as most girder rails are rolled.

The radius of the curves at the gage lines should also be such as to bring the flange pressure under traffic conditions well below the edge of the rail, as illustrated in Fig. 3.

Analyzing the occurrence and non-occurrence of corrugations on the basis of this theory, it is not difficult to see why corrugations rarely occur on steam roads. Not only is the rail free to adjust itself so that the point of maximum intensity of pressure falls near the center of the head, but the shape of the head is such as to obtain this result even though the rail was not free to move.

In the exceptional cases where slight evidences of corrugations have been found in steam roads, in yards or near stations, the cubical elastic limit of the steel of the rail has undoubtedly been exceeded. This is due to the combination of wheel loads and tractive forces exerted in starting and stopping trains, and as the positive or negative acceleration is not uniform the result is a non-uniformity of pressure. On some curves where there is no doubt that the cubical elastic limit of steel has been passed.

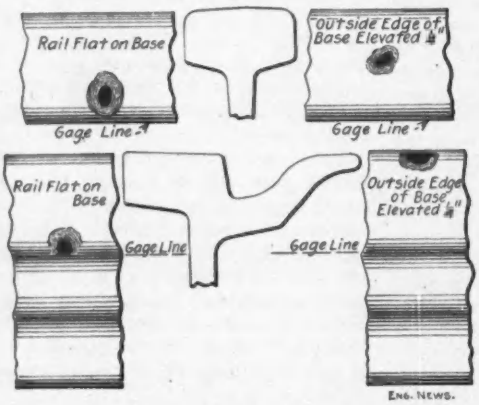

FIG. 1

(Showing change of location of area of contact due to elevating outside edge of base of rail ¼ in.)

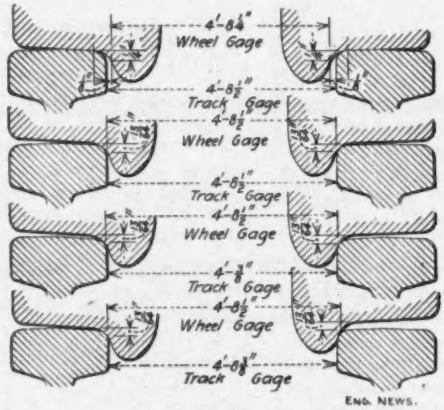

FIG. 2

(Showing relation of car wheel to rail under different conditions.)

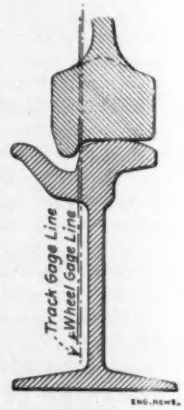

FIG. 3

(Rail section modified to make the surface of rail head the arc of a circle instead of a plane.)

but where there is no necessity for stopping and starting, a uniform cold flowing of the metal of the steel of the rail will be found. The same argument holds, of course, for interurban track.

With nearly all T-rails in paved streets the shape of the rail head tends to keep the point of maximum intensity of pressure near the center, but as the rail is not free to move, all the cases illustrated in Fig. 2 (except the top one) can produce corrugation. In the case of outside rails on long-radius curves, the wheel flange presses against the side of the rail, the pressure varying with the speed. When the rail is not properly shaped, the tendency is for the wheel to climb the rail, lifting the tread of the wheel from the rail surface and bringing the maximum intensity of pressure at the very edge of the rail. As soon as this pressure exceeds the linear elastic limit, deformation occurs and the wheel drops until the area of contact is sufficient to reduce the pressure below the elastic limit when the wheel again starts to climb. As the time required for the wheel to drop a certain distance is consant and the speed of the cars varies, it will readily be seen that the length of corrugation thus produced will be a function of the speed of the cars.

Quite a different effect is obtained, of course, on short-radius curves. In the first place the speed is not sufficient to cause climbing due to flange pressure and as the inside of the flange makes contact with the guard, the area of contact is certain to keep the maximum intensity of pressure below the elastic limit, even if the point of maximum intensity fell near the edge, which it does not, as shown by the wear on the guard. This theory further explains why, in many cases grinding removes corrugations and why in others it does not. If the grinding simply removes the inequalities of the rail surface without changing the relation of wheel tread and rail surface, corrugations will again appear; while if the grinding does change this relation, taking the center of pressure away from the edge of the rail, corrugations will not occur.

[A proof of the above letter was submitted to Mr. Mohler, and his reply is given below.—Ed.]

Sir: I wish to correct a slight error in the text of the article, ENGINEERING NEWS, Nov. 30, before replying to Mr. Pellissier. On page 657, near the top of the first column, the sentence reading "front faces of the rear axle brought," etc., should read: "front faces of the front axle with inside and the front face of the rear axle for outside hung brake are brought," etc.

My article was prepared and given to ENGINEERING NEWS some time before Mr. Pellissier's exposition appeared, so that his theory was not given a "curt dismissal" at that time. As to why he objects to the dismissal of theories that do not coincide with or support his own is not clear. With the "curt dismissal of the theories already advanced" I left myself some room to "hedge" as follows: "All of the above may be dismissed from consideration as the true cause," etc.; "Many of them have a secondary influence."

Anyone can safetly say that two wheels of the same diameter rigidly fastened to the same axle (like ordinary car equipment), in rolling around a curve will slip both longitudinally and transversely. As to what kind of wear produces the corrugation, will depend on the conditions. A very hard rail would probably wear out by abrasion. A soft rail would both wear out and flow. On some sharp curves in Chicago the inner rail has changed from a bevel on the outside to a groove where the original bevel existed. This is apparently by the flow of the metal rather than by abrasion.

I think I am almost safe in commending the article to Mr. Pellissier for a more careful and painstaking reading than he appears to have given it. I thought the long-radius curve question was covered by the stater ent that the rotation of the truck to follow the curve caused the wheels to slip. It will require considerable force to cause the wheels to slip to change direction. That force applied will cause stresses in the truck frame and track, etc. Take your wheel load 10,000 lb.; coefficient of friction 0.2; necessary force to produce slipping of one wheel is $10{,}000 \times 0.2$, or 2000 lb. To slip two wheels of a truck, 4000 lb. I think any one will concede that amount of stress will produce considerable deformation in the ordinary truck and track.

As is well known, sliding friction is less than rolling friction. After slipping is actually started the stresses set up in the truck and track will react with a spring and carry the wheels to a position where they will leave the equipment stressed equal to the sliding friction. Say for the sake of illustration the sliding friction is half that of rolling, and that under the rolling friction the truck is deformed one onch out of square. Then the forces acting after the adjustment of sliding friction will be one-half and the deformation also one-half. As the car is usually in rapid motion the reaction or adjustment will cover more or less distance, as the reaction cannot well be absolutely instantaneous.

One question raised is: why does corrugation appear at one point and not at another under identically the same conditions? As far as my observation goes, I know of no reason why identical conditions should not produce identical results. The laws of nature's forces are not erratic. Is it certain that all of the conditions are alike, even though they appear to be so.

Under the heading "Electrical Operation. Straight Track," I made this statement which was quoted in part by Mr. Pellissier, "With straight-track of T or flat-lip girder rail on uniform foundation and smooth clean rolling surface, corrugation should be slow in developing." Here is what he says, "It is stated by the author that corrugations should be slow in developing on T-rail and on straight-lipped rail, although it is not apparent why the slipping should not occur on these rails on curves and where the brakes are applied in just the same way as on grooved rails."

I took a great deal of pains to classify each kind of operation for the express purpose of making it perfectly clear what was being considered and the limitations in each, so as to avoid just such mistakes as above. I did not say that curved track of that kind would not corrugate. It may or may not.

I wonder if a large contributing factor to a trouble is to be thrown out from consideration and disregarded because it may not be the whole thing. I refer to the part that the flange rolling on the groove of the opposite rail plays in starting and carrying on corrugation. I left room to "side slip" on rough track, etc., so that I can blame that and other causes for corrugation if I wish to. I would expect to furnish the evidence in any particular case, on which to base conclusions.

My observation has been that corrugation occurs on both outer and inner rails of curves. I do not know of any reason why it should not do so, as side slipping of the wheels on the rails is "probably" a factor together with the longitudinal.

If Fig. 10 (Nov. 30) is looked at closely it will be seen that the center of the bright-spot is pretty well to the left of the frog point. Some of this wear is caused by the flange of the wheel striking the side of the groove and pulling the wheel over. That will produce side slipping and wear in addition to the longitudinal resulting from the unequal rolling diameter of the wheels. That, of course, will leave us on the horns of a dilemma as all kinds of slipping are discredited factors. I may be mistaken, but an obstruction like the riser through a frog should be about as effective in causing excess wear in the opposite rail as a drop in passing the frog gap. In this particular case the shallow groove carried the flange through the frog.

As previously stated a stressed truck and track cannot recover its decreased stress form instantly. When some point in the track is reached where greater resistance is offered to rolling, say on the outer rail, the trucks and tracks would have to undergo added stress before the obstruction was passed. At the instant the obstruction or extra resistance was passed the tendency would be for the accumulated stress in the trucks and track to force slipping of the wheels. Take the passage of a wheel over a developed ridge of corrugation, say an outer wheel. As the wheel rolls up the ridge it (with its load) will have to be lifted until the crest is reached. During this time the truck and track are already stressed on account of having to slip the wheels to change their direction. With the speed and climbing the incline slipping cannot readily take place till the crest is passed. At that instant the pressure on the rail will be slightly reduced and the reaction

will cause slipping at some point or points as the wheel passes through the depression.

A few words on Mr. Pellissier's theory: The T-rail with its rounded head seems to possess in his estimation most of the desired immunity against corrugation. Under steam operation it rarely develops. Under electric operation he has this to say: "The fact is, however, that under certain conditions of electrical operation, corrugations appear very rapidly on T-rail on a uniform solid foundation, as may be verified by reference to the proceedings of the American Electric Railway Association." As the wheel loads are greater on steam roads than on electric, why is not the corrugation on the steam road the greater when the rail head is the same in both cases?

If the contact of the wheel near the edge of the rail head is responsible for the abnomal flow and wear resulting in corrugation, how does it come that the exposed edge of the rail at the end in joints holds its own so well? Here we have a vertical face meeting the surface at right angles. The joint space is sometimes over ½ in. wide. The joint splice is the weak spot in the track. If the "cubic elacticity" can get away and become lineal at any place and cause trouble it certainly has its chance here. As a matter of fact the actual wear and burring of the rails at the joint rail ends is very little. It is well known that most of the wear and pounding of joints is from six to eight inches beyond the rail ends. I have seen steel rails that have been in service for over 20 years on steam roads without any mashing or burring of the end.

To show that the rolling pressure and contact of the wheel on the rail with as light loads as carried by electric cars is a slight factor in excess rail wear as compared to rubbing or sliding, I may use the following illustrations:

(1) Take a grindstone weighing 100 lb.; that could be rolled over the top of a rail for almost an indefinite period without producing any wear on the rail head. Even so, if the weight of the stone rested on a single grain of sand at any time the elastic limit may well be exceeded.

(2) Allow the stone to rest in one position and apply power to turn it. The rail is rapidly ground away and a large area of contact produced. Still as long as the stone turns the wear continues. The vertical pressure is certainly a small factor in producing the marked results.

(3) Suppose the grindstone is rolled along the rail and turned so that its plane is at an angle to the rail. Then to keep the stone from rolling off it will have to be held to its course. Side slipping will result in proportion to the sine of the angle its plane makes with the rail. If it is held to its course by a flexible frame that can be deflected under stress, then until the frame is stressed the grindstone will roll ahead in its own plane. When the frame has been sufficiently stressed the grindstone will be brought back to position and constrained to move along the rail.

As soon as its direction is changed it has to slip at the point of contact. When slipping starts, the stress in the frame will carry it back to about the position determined by the amount of the stress set up from sliding friction. Under such conditions instead of moving along a straight line it will take a zigzag course along the rail. If many thousands of grindstones (all similar and controlled in the same way) passed over the rail it would not be surprising if they got to moving in about the same zigzag path. That, of course, would mean ridges and furrows would result with the very light pressures assumed.

A piece of iron or steel can be filed with a dull file without putting a normal pressure on it to exceed the elastic limit of the material filed. The same is true of grinding.

Perhaps one of the easiest ways for Mr. Pellissier to prove his theory will be to have the rails ground to the rounded section which he considers so essential when grinding is resorted to for the removal of corrugations.

If my critic will allow the use of a "probability" I may suggest a reason why corrugation is more prevalent on rigid T-rail track in paved streets than it is on less rigid open track. New track with ordinary fastenings is fairly rigid. The side stresses brought on the curves in slipping the wheels and changing their direction are such that the ordinary spikes will gradually give way and loosen. Suppose at the start any particular point offered greater resistance to lateral movement or spring than is offered on each side of that point. The natural "tendency" will be for excess stress to be concentrated at that point and also the "probability" of corrugation developing. Before that has actually taken place the fastening will have been loosened or forced to give way so as to distribute the excess stress. That process will be repeated until the whole track is pretty flexible. With a loose and wabbly track, a sharp reaction between the track and truck under stress can hardly take place, and the "tendency" to slip at intervals in the same succession is largely if not entirely destroyed. Let me illustrate again by the simple process of filing. Suppose it is wished to file a diagonal notch in a small bar of iron in an exact position. You will naturally fasten the bar so that it is firm and rigid, and the task will be an easy one. If it is lying loose, you will not be able to accomplish your undertaking.

While some of the questions raised are germane to the subject, others do not appear to me to be so.

CHARLES K. MOHLER.

116 So. Michigan Ave., Chicago, Dec. 19, 1911.

The Alluvial Soils of the Colorado and the Mississippi Deltas

Sir: Experience as a levee builder along the Mississippi River does not finish one's education as a builder of levees along the Colorado River, of which, evidence is found in, "How the United States Spent a Million Dollars in an Ineffectual Attempt to Control the Lower Colorado River," appearing on pp. 667 to 673 of your issue of Dec. 7, 1911.

It is probable that the minor flood in the Colorado would have had no injurious effect on the levee if the latter had been built of the soil of the Mississippi Valley. Between the latter and the light friable soil of the Colorado, there is a great difference in stability. The unprotected condition of the Colorado levee was sheer folly and a natural result followed.

No engineer can afford to discredit himself, his peers and civil engineering by accepting great responsibility in a project in which the unprotected slopes of a levee built of the friable silt of the Lower Colorado are left exposed to the attacks of the fierce floods of that great river.

Yours truly,

J. L. CAMPBELL.

El Paso, Tex., Dec. 18, 1911.

Compensation of Engineers: "Suasion" Recommended

Sir: The writer has read with interest various articles in your journal as regards inadequate pay of engineers as a class. Some seem to have a horror of trade-union methods for increasing their pay, but after all is said and done what is the objection to these methods? Does not the workman often see things more clearly than the professional man? He has no mistaken pride to balk him. He knows what he wants and he goes after it. He organizes and brings the power of organization to bear on getting a living wage. There are scores of designers of ability and worth who are getting less for their toil and ability than the operators (they are not machinists) who run the machines designed. Similar conditions in England are described in an editorial in the Nov. 17 issue of London "Engineering."

Reprehensible though it be, it is a fact that with the exception of an employer here and there the wage question is a question of "hold-up," a question of force. "How much can I make him pay?" and "For how little can I get him to work for me?" It is this sort of a proposition from end to end.

Professional pride is all right in its place, but like Senatorial courtesy, it may be the cause of a lot of evil. If we want precedent ,there are the fixed fees of those most professional of all the professions, the medical and the legal fraternities.

Now, brother engineers, the workman has "the right pig by the ear," as Henry the Eighth said of Cranmer. Get together then, you engineers, on a common-sense basis and with your other methods for gaining adequate compensation use a little "suasion."

Wm. B. Rainsford.

Indian Head, Md.
Dec. 13, 1911.

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Engineering News

Over a Half-Century of Service as City Engineer

At the possible risk of repetition, we inquire whether any of our readers know of an American city engineer who has served one city in that capacity for a half century. Such was the record of T. H. Yabbicom, who recently resigned as city engineer of Bristol, England, "after more than fifty years' service" (London *Surveyor*, Dec. 8, 1911). As a fitting celebration of the termination of such a long official career, the mayor and numerous other city officials of Bristol gave Mr. Yabbicom various articles of silver at a dinner of the Bristol Municipal Officers' Association.

A British record of almost as great length was that of W. H. Wheeler who, in 1908, was presented with a 150-oz. silver tray on removing from Boston, England, after serving as borough surveyor and harbor engineer. In the same year, Mr. Philip C. Lockwood, of Brighton, England, died after serving that borough as surveyor from 1858 to 1888, and as consulting engineer from 1888 to 1904. Another remarkable British record was the service of the two Bothams, father and son, as city surveyor of Salisbury, England, for 55 years (1853 to 1908).

The longest American record of which we have knowledge is that of Thomas Murray who, in 1908, was elected to his fortieth term as city engineer of Davenport, Ia. (and who may still be serving in the same capacity). The next to the longest American record of which we know was that of Col. W. E. Cutshaw, who died in 1908, after having served as city engineer of Richmond, Va., for 34 years.

We do not question but what many American cities have recognized meritorious service by retaining city engineers and other officials with technical training for many years, but, as many of our readers know only too well, this is the exception rather than the rule, particularly where now one and now another political party is in local control. It is quite unnecessary to advance arguments for the retention of competent, faithful municipal servants in office during efficiency and good behavior, be they engineers or laymen.

Making the Hudson River a Ship Channel

A public hearing was recently held at Albany, N. Y., by Col. Wm. M. Black, Corps of Engineers, with reference to the project to deepen the Hudson River so that ocean vessels may ascend to Albany and Troy, 150 miles from the sea. A strong argument in favor of the project was made by Mortimer G. Barnes, who is one of the consulting engineers on the New York State Barge Canal work. The Federal government has already appropriated some $5,000,000 for the improvement of the Hudson River so as to provide broad channels, with a minimum depth of 12 ft., to Albany and Troy. Mr. Barnes estimates that by increasing this appropriation to $15,000,000 a channel 21 ft. deep could be made to Albany and Troy, with a width of 600 ft. to Staats Landing and 400 ft. to North Albany. For $6,250,000 additional the depth of the channel could be increased to 25 ft.

As most of our readers are aware, the Hudson River is really an arm of the sea. Deep water in the stream in its natural condition extends more than half way from New York City to Albany. There is certainly no place in the United States, with the possible exception of the Mississippi River, where a channel can be made at small expense by which ocean vessels could sail so far inland as on the Hudson River.

The traffic conditions, moreover, are unusually favorable for a ship-canal project. On the Mississippi, an ocean vessel would have no object in sailing farther up than New Orleans, for there are no commercial cities of any size at which it could find cargo. At the head of navigation on the Hudson, however, the cities of Albany, Troy and Schenectady, with their surrounding municipalities, form one of the largest centers of population in the East. The Hudson River already carries a traffic above five million tons per annum. Moreover, the channel is straight and broad, with few dangerous obstructions. An ocean vessel, with the river deepened to 25 ft., could sail up the stream and deliver its cargo at Albany, making nearly as good speed up the river as it could on the open seas, and with very little greater danger of injury by collision or grounding than in New York harbor itself.

All these conditions strongly favor the project, and most of them exist at no other point where ship canals have been agitated for. If, then, there be any place where it will pay to extend ocean navigation inland, the Hudson River is such a place. On the other hand, it can be readily seen that the commercial interests of New York City will without doubt be strongly arrayed against any such project. New York City would derive neither pleasure nor profit from seeing ocean steamers sail past it up the Hudson to discharge their cargo at a port 150 miles to the northward. There would be as little enthusiasm in New York over such a project as there was in Liverpool, England, over the building of the Manchester Ship Canal.

Of course, if such a channel would really attract a large number of ocean-going vessels, the opposition of New York City ought not to prevent its being made. The most economic route for transportation ought to be created, regardless of the interest of particular terminal cities. There is, however, room for doubt as to whether, if the proposed 21-ft. or 25-ft. channel to Albany were actually created, it would be taken advantage of to any great extent by ocean vessels. So far as traffic over the New York Barge Canal is concerned, when that channel is completed, barges coming through the canal from Buffalo on the west, or from Lake Champlain on the north, can pass down the Hudson River and discharge their cargoes at New York City more cheaply than ocean vessels could go to Albany to meet them. It has been often pointed out that transportation by barges is cheaper by far than transportation in ocean vessels. The cost of a barge per ton of carrying capacity is only a small portion of the cost of an ocean steamer, and the cost of loading and unloading a barge is very much less than the cost of

lowering freight into or hoisting it out of the deep holds of an ocean vessel.

The one factor which might be powerful enough to induce the passage of ocean vessels beyond New York City is the steady increase in cost of handling freight in this crowded port. It is quite possible that this may reach a point which will justify the creation of new terminals located farther inland. There has been more or less talk, indeed, of developing such terminals at Montauk Point on the eastern end of Long Island and also at New London on Long Island Sound. A terminal located at the head of navigation on the Hudson River, however, would manifestly have a vast advantage over either of these locations. The promoters of the project, however, must reckon upon the opposition of New York City, with its large Congressional representation. The influence of Massachusetts, too, would doubtless be thrown against such a project, since the development of a port at Albany would take away much of the traffic to and from the West which now passes through the port of Boston.

The Report of the Railroad Securities Commission

The report of the Federal Commission appointed by President Taft to consider the question whether the Federal Government should control the issue of stocks and bonds by railway companies deserves to be given great weight because of the unusual personnel of the Commission. To mention only two of its members, its chairman, President Hadley, has made a special study of railway economics for many years and was at one time a member of the editorial staff of the *Railroad Gazette;* B. H. Meyer is one of the foremost authorities on railway economics in this or any country, and by his remarkable work in the development of railway regulation in his own State of Wisconsin, achieved a distinction which fully justified his appointment to the Interstate Commerce Commission by President Taft. The unanimous opinion of these men, with their equally distinguished associates, ought to have great weight with Congress and with the public.

There is no denying, however, that to a considerable section of the public the main conclusions of the Commission are somewhat of a surprise. While the Commission bases its recommendation that there be no regulation of stock and bond issues by the Federal Government on the ground that this is a responsibility belonging to the States themselves, there is the evident implication in its report that state regulation of the capitalization of corporations is likewise of doubtful wisdom.

That the Commission's reasons are sound as to Federal interference in this field will generally be agreed. There will be more or less dissent, however, from the second proposition, that there should be no State interference with the issues of securities by public-service corporations. The tendency in progressive states, particularly those where public service commissions have been created, has been to put some sort of limit on stock and bond issues by such corporations and to place them under the supervision of the commission.

It is entirely true, as the Commission says, that such common statutory requirements as that stock shall only be issued when its par value has been fully paid, are of little real efficacy for the protection of the public. On the other hand, the abuses which have become flagrant as the result of allowing corporations to issue securities wholly without restriction have created a strong public demand for some sort of government limitation upon the issue of securities for the protection of the investing public.

The Commission's position is that the investor must take care of himself and that the only valid reason for the state controlling stock and bond issues would be to safeguard the public from excessive rates. But in the opinion of the Commission the capitalization of a corporation ought not to be taken into account in fixing what rates it may reasonably charge. What should govern that is not the volume of stocks and bonds but the actual value of the corporation's property.

To the end that this may be determined, the Securities Commission recommends that the Interstate Commerce Commission should have authority and adequate funds to make a valuation of the railways of the United States whenever it deems such a valuation of importance. The Interstate Commerce Commission has in fact repeatedly requested Congress to give to it the authority and funds for making such a valuation and renews this request in its annual report just issued.

It is further worthy of note that the Interstate Commerce Commission has hitherto gone on record in favor of Federal control of railway capitalization in some form. Important and weighty though the report of the Hadley commission is, therefore, it is doubtless not the last word to be heard upon the subject.

Whither Are We Tending?

The engineer engaged on a reconnaissance survey sometimes becomes puzzled by the topography about him. He finds himself surrounded by hills which limit his vision, intersected by a labyrinth of valleys, and he is at a loss in which direction to turn to carry his survey forward. Many an engineer under such conditions has been able to solve the riddle before him by climbing some mountain height in the near vicinity, from which he can obtain a broad view of the country. Seen from such a viewpoint, the difficulties disappear. The low hills and intersecting valleys which confused the observer when close to them are seen now in their proper relation to the larger features of the landscape.

The engineer can see the main valley along which he has been proceeding, and can follow it far backward along his course. Turning in the other direction he is often able to follow the same valley far in the distance, and so determine whither his future steps are to lead.

It is sometimes advantageous to apply the same method to the study of social and political and economic conditions. It is a good plan to leave for the time being the things immediately round us, which bulk so large in our vision, and to attempt to reach some summit from which one can view in broad perspective a long range of events and determine the underlying causes which bring them to pass. The beginning of a new year is an appropriate time to attempt such a broad view, especially when the surrounding events are such that they may well puzzle the beholder and fill him with doubt as to whither the world is tending. A cartoon in the current number of *Life* depicts the Earth as a lonesome wayfarer toiling timorously along through the darkness of space, while about it play the threatening lightnings of anarchy, riot, war and kindred horrors.

It cannot be denied that to one who views the world's events happening day by day, there is much to cause doubt and foreboding. The demon of discontent—if discontent be indeed a demon—is abroad in this land and in every land. Everywhere there is social unrest. Two European nations are at war. The oldest nation in the world, China, is in the throes of a revolution. In two of the subject nations of the world, Egypt and India, there is a widespread discontent and disloyalty to the existing government. In France during the past year a strike of employees on the government railways caused great distress and suffering, as well as an enormous financial loss. In Great Britain an unparalled strike of all railway employees paralyzed trade and industry and exhausted the store of provisions in many communities. A compromise agreement averted more serious results, but it is well understood that the agreement will not long satisfy the employees. In Germany, the most efficiently governed country in the world, notwithstanding the vast strides which have been made in the adoption of so called socialistic methods of ameliorating the conditions of the working classes, socialism increases by leaps and bounds.

Turning to conditions at home, we find the same evidences of widespread social discontent. The dynamite outrage at Los Angeles with the terrible loss of life, and

the dynamite outrages at hundreds of other places where no loss of life occurred, but where valuable property was wantonly destroyed, are most of all important because of their evidence of deep-seated class hatred.

Political conditions are no less eloquent of the social unrest. The old party names have lost their hold on the voters. Nominees of the Socialist party have won elections in a number of American cities, a few of them of large size, and the first Socialist member has entered Congress. In the recent election in Los Angeles, in which a Socialist candidate for the Mayoralty was defeated, the successful candidate was elected on a platform involving a large extension of municipal ownership, enough to have fully entitled him to have been called a Socialist candidate in any Eastern city ten years ago.

Such are only a few of the typical events and conditions which seem closest to us at the beginning of this year of 1912. What do they all mean? Whither is the world tending? Such questions as these are being asked by hundreds of thousands of intelligent people.

May we not imitate the puzzled surveyor who climbs a mountain peak to solve his doubts as to the topography about him? If, like him, we look far back along the course which has been traveled, we see in the records of history evidences of a broad valley cutting irresistibly through the chaos of events just as a valley in a distant landscape threads its course through hills, along mountain chains, and past giant promontories. That valley we may call, *regard for human rights.*

The thing of greatest interest to the thoughtful student of English history is not the events in the lives of the kings and queens and barons who held sway over the land. It is the steady, resistless growth of regard for human rights. Liberty is the name under which this idea has appealed to the race for centuries, the name which has inspired thousands and millions to sacrifice their lives for its defense.

To the observer at the time, these sacrifices have often seemed wasted and useless. Those English artisans who led a forlorn hope in rebellion after rebellion during the Middle Ages and later, and whose severed heads were placed on city gates when the rebellion was quelled, seemed at the time to have accomplished nothing. The restoration of the Monarchy after Cromwell seemed to have made worthless the work of the revolutionary leaders. But is was only seeming. The underlying idea was steadily growing all through the nation, and through other nations at the same time. Most of all did it find soil for rapid development among those who had come to a new world on this side of the Atlantic, and who, by heroic battle with the wilderness had developed a self-reliance and independence such as a people living for generations under the iron rule of despotism could never know.

The American Revolution of 1775 was chiefly significant, not in the separation of the Colonies from the mother countdy, but in its establishment of popular government. The bloody French Revolution followed shortly afterward, and while its crimes and excesses seemed to check the progress of liberty and lay the foundation for the despotic mastery of Europe by Napoleon, the growth of the idea went on just the same.

One has only to follow the course of that great valley through the nineteenth century to see it marked broad and deep all through the seeming confusion of events. That century witnessed the passing of slavery and the slave trade from the civilized world and the extension of some form of civil government over nearly all those parts of the globe where barbarism had always held sway. It witnessed a marvelous liberalizing and humanizing of laws and customs in the chief nations of the world, the elimination of pain and torture and suffering and oppression and misery, so that the man of today lives in an absolutely different world from that in which his ancestor struggled for existence a century ago.

The course of that valley did not terminate with the nineteenth century. It was indeed the idea of the dreamers whose theories influenced the political revolutions of a century ago, that with the end of slavery and the establishment of popular government, the struggle for liberty would be achieved. In the last two-score years, however, it has become evident that economic liberty is as essential to "the pursuit of happiness" as is political liberty, and the battle for it is being waged as vigorously as was the fight for political liberty a century ago.

The past quarter-century and especially the years since the twentieth century began have been chiefly notable for the progress which has been made along this line. Nowhere has progress been more remarkable than in England, especially during the past three years. These have witnessed the passage of the land-tax bill, by which the owners of land have to pay over to the state a part of the "unearned increment" when their land increases in value, the passage of the bill by which the power of the British aristocracy, as represented by the House of Lords, to control the government is finally ended, and the introduction in the present Parliament by the Liberal Government of a bill under which insurance is to be furnished by the nation for those who are placed in need by sickness, accident, loss of employment or the infirmities of old age.

The most striking fact with reference to this last-named bill is that while it is originated and put in force by the Liberal Government, its passage through Parliament is practically unopposed by the so called Conservative party. The statesmen of Conservative and Liberal parties alike have recognized that the economic situation of England's working classes demands that measures be taken to alleviate their condition. The hunger strikes of the unemployed in the principal industrial cities of Great Britain during 1908 and the great railway strike of the year just closed are danger signals which a statesman cannot but heed.

These measures would have been called radical and revolutionary by the England of a quarter-century ago, probably even of a dozen years ago, and many people on this side of the Atlantic consider them radical and revolutionary today. But everyone knows that these measures represent a permanent alteration in political and economic conditions. No party will undertake their repeal, no matter what political changes may occur.

In our own country a similar revolution is going on. Dozens of examples could be given to show the trend of events. Those whose memories extend back more than a score of years can recall the days when public utility corporations were run exactly as if they were private concerns. "The public be damned" was not important as the explosive utterance of a multimillionaire. It *was* important as expressing the attitude toward the public of many of the corporation magnates of that day. But today one would search far to find a responsible officer of a railway or other public-service corporation who does not assent to the principle that some measure of control over such corporations must be exercized by the state to secure the public its rights.

Thirty years ago there was no limit to the profits which might be reaped from the exploiting of a valuable franchise and an army of promoters was going up and down the country begging and buying franchises in every city not already gridironed with rails and pipes and wires. The price, however, when a price was paid, went to aldermen, or other city officials, and there was hardly a thought of any part of the profits from the use of the franchise reverting to the public treasury.

We have traveled far since those days, and the principle that franchises should be given only for a limited term of years is now embodied in many state constitutions. Other states have enacted laws subjecting franchises to taxation. More important still is the enactment of laws and the development of court decisions under which the profits of franchise corporations holding a monopoly are limited to what will yield a fair return on the capital actually invested. Coincident with this has been the enactment of public-service laws and the establishment of public-service commissions which limit the rates that may be charged by public-

service corporations to a reasonable figure and require them to render good service.

Barely half a dozen years ago, President Roosevelt called public attention to the fact that the United States is the only great industrial nation which has not adopted a modern system of compensating workmen injured in industrial accidents. A chorus of indignant protest at once went up from corporation representatives; but the protest might as well have never been uttered. All over the country work began at once on the preparation of new laws governing workmen's compensation and in a number of states these new laws are already on the statute book. Most notable of all is the fact that associations of employers are taking a leading part in the study of the question and the drafting of the new laws.

We might give a dozen or a hundred other illustrations to show the progress which has been made in the past quarter-century, but there is no need. That dominating valley in historic topography which we have called "Regard for Human Rights" is evident to anyone who will view the landscape impartially from a high altitude. It is true that the mist obstructs the vision as one gazes in the opposite direction and endeavors to read the riddle of futurity; but there can be little doubt that the course of the valley is the same.

The race is not going backward from self-government to despotism, or from liberty to slavery. Changes and obstructions there will be in the future, doubtless, as there have been in the past, but they will not permanently alter the course of the valley. Like the avalanches which fall into an Alpine current, they can do no more than temporarily check the flow of the stream, after which it sweeps forward with greater impetus than before.

In what we have said thus far, we have done nothing more than record facts. The most ultra-conservative "stand-patter," if he be an intelligent and impartial observer, must see that valley which we have described, cutting its path through the jumble of historic events.

That the course of that valley is beset with grave dangers no keen observer, whether he be progressive or conservative, can deny. Never was there greater need than at the present day of wise statesmen to meet these perils as they arise, and of intelligence and a law-abiding spirit widely disseminated among the people to give support to right measures and competent men in charge of affairs.

Liberty has degenerated into license in the past and may do so again. The under dog in the battle for existence has sometimes become a wolf when released; yet released he must be. He cannot permanently be held in subjection.

Again the complex organization of Society today is far more vulnerable than the simpler system of earlier times. The labor-saving machinery which the engineer has created in every department of industry and transportation has tied the whole world together and has enabled food and clothing and shelter to be provided for millions where a barbaric society could only keep thousands alive. But stop the working of this complex machinery at any point by violent means, and the lives of millions are out in peril.

We are far from belittling these dangers which threaten Society or denying that many of them are brought upon us through that ceaseless struggle for larger economic liberty which we have been depicting. But we cannot avoid these dangers by any attempt to dam up the stream which flows down the valley. Any such attempt will only add to its head and increase the destruction wrought when the dam breaks.

If the view from the summit can teach any lesson, it is the futility of any such attempt to change the course of the valley by blocking the stream. The wise engineer adopts no such plan, but seeks to work with the current instead of against it; to guide it by levees and training walls so that its energy may be directed into safe channels and to direct its power wherever possible to the service and benefit of the race.

Owing to the delay in mails over the holiday and to some further calculations that the author wished to make, the continuation of the article by T. L. Condron, on the collapse of the Prest-O-Lite Building in Indianapolis, Ind., will not appear until our issue of Jan. 11.

Some Babylonian Building Regulations said to have been established more than four thousand years ago, are given in the introduction to a paper entitled "The Influence of Building Regulations on Architecture," by H. D. Searles-Wood, printed in the journal of the Royal Sanitary Institute for December, 1911. The regulations, which are found in the laws of Khammurabi, are as follows:

ccxxix. If a builder build a house for a man and has not made his work strong, and the house has fallen in and killed the owner of the house, then that builder shall be put to death.

ccxxx. If it kill the son of the owner of the house, the son of that builder they shall kill.

ccxxxi. If it kill the slave of the owner of the house, a slave equivalent to that slave to the owner of the house he shall give.

ccxxxii. If the property of the owner of the house it destroys, whatsoever it destroys he shall make good, and as regards the house he built and it fell, with his own property, he shall rebuild the ruined house.

ccxxxiii. If he build a house for a man and did not set his work, and the walls topple over, that builder from his own money shall make that wall strong.

As the author well says, these laws are based on the principle of a life for a life. He expresses the opinion that the first designer of the pyramids had these laws in mind and built them so as not to take any chances of punishment for himself or family through the falling of the pyramids.

The Pittsburg Smoke Ordinance

The emission of smoke from chimneys within the corporate limits of Pittsburg is now regulated by an ordinance passed by the City Council on Sept. 19, 1911, and approved by the mayor on Sept. 22.

Section 1 of the Pittsburg ordinance provides that no steam boiler or other furnace, except in private residences, mill heating furnaces, and puddling furnaces shall be constructed within the corporate limits of the city until the owner, agent or lessee has made application at the office of the chief smoke inspector, and has had his plans for the dimensions of boiler or furnace, height of stack or chimney, and method of preventing dense black or dense gray smoke, aproved by the inspector. The devices and methods may provide, however, for the emission of dense black or dense gray smoke for eight minutes in any one hour.

The second section provides that every boiler furnace or other furnace (except as before in private residences, mill heating furnaces and puddling furnaces) in which bituminous coal is burned as fuel, shall be so constructed or altered to prevent the production of dense black or dense gray smoke except for 8 min. in any one hour. All owners and lessees of such boilers and furnaces are forbidden to permit the use of the plant without some method of stoking which prevents the emission of the objectionable (dense black or dense gray) smoke for more than eight minutes in any one hour.

The third section of the ordinance provides that a permit or certificate for the reconstruction or construction of any plant or chimney shall not exempt an owner or lessee from prosecution on account of the emission of smoke in violation of the ordinance.

Section 4 provides that deputy smoke inspectors shall personally inspect all chimneys, steam-generating plants and any furnace apparatus, except in the same exempt classes noted. The chief inspector and his deputies have the power to examine and supervise the igniting, stoking, feeding and the tending of boilers and furnace fires. They have the authority to enter any boiler, or engine room, or building from which objectionable smoke is being emittedfi or has been during 24 hours previous.

Section 5 provides that violation of the ordinance shall be the base of complaint from the chief smoke inspector to the offender. If the cause is unskillful stoking, the chief inspector shall cause one of his assistants to give proper instruction for correction. If the trouble is owing to the faulty construction of the

furnace, or to size or height of stack, or other engineering details, he shall advise the owners or operators as to the necessary changes, alterations or additions which should be made. When the cause of offensive smoke lies in faulty engineering details, six months is allowed for alterations or repairs. When the offenses are due to organic troubles of a plant, such as continuous overload, then the chief inspector may order such changes or additions as are necessary, and nine months is to be allowed for completing the work.

Section 6 provides that all accidents to furnaces, or smoke-preventing devices shall be reported within 72 hours to the chief inspector.

Section 7 provides that during the first hour in which a new fire is being kindled in a cold plant, except in the exempt classes, dense black or dense gray smoke may be emitted from the chimney or stack for 60 minutes once a day for the first year of the ordinance, 45 minutes once a day during the second year, and 30 minutes once a day during the third year and thereafter.

In Section 8, "dense black" and "dense gray" smoke is defined in accordance with the Ringlemann smoke scale, as supplied by the U. S. Geological Survey. The third shade on this scale is to be known as "dense gray," and the fourth shade as "dense black." Owners, officers, managers or agents of any corporation in any way controlling a furnace, boiler, heating, power or manufacturing plant, locomotive, portable engine, portable boiler, street roller, motor vehicle, steamboat, stationary engine, or similar device, from which objectionable smoke is emitted, may be tried for violation of the ordinance before an alderman or police magistrate. In case of conviction, the fine is to be made not less than $10, nor more than $100. In default of payment of fine and costs, the offenders are to be committed to the workhouse for not exceeding 30 days for each offense. Each day in which objectionable smoke is emitted constitutes a separate and distinct offense.

An Excessive Run-off from a Small Drainage Area Near Hartford, Conn.

By W. L. Butcher*

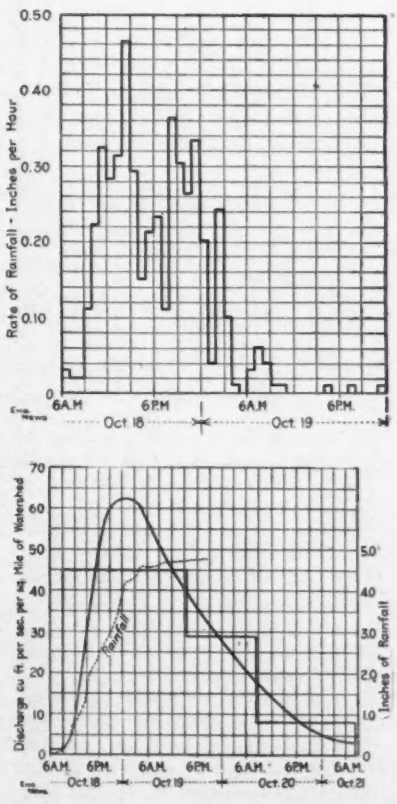
While engaged during the autumn of 1911 on certain construction work connected with a storage reservoir in western Connecticut, the writer witnessed a rather remarkable discharge from a small drainage area. As is usually the case under like conditions when, through the destruction of reference marks, or otherwise, the data are difficult to obtain, the ascertained facts are not all that could be desired. Certain measurements, however, made as soon as the abnormal conditions were recognized, may be of interest.

During the early part of October there was an unusual amount of distributed precipitation. According to the local Weather Bureau at Hartford, about 20 miles distant, precipitation had occurred as follows:

1911	Inches
Oct. 1	0.97
Oct. 2	0.22
Oct. 4	0.23
Oct. 6	0.05
Oct. 7	0.34
Oct. 17	0.03
Total to Oct. 18	1.84

This precipitation, while not excessive, may be seen to have been well distributed in such a way as to reduce the depleted ground storage.

On Oct. 18 and 19 there occurred a rainfall of 4.78 in., most of which fell within a 24-hr. period. During this same period a fall of 5.8 in. was recorded by a gage on the drainage area under consideration. This fall was so much in excess of that officially recorded at Hartford that a study was made of the precipitation at other U. S. Weather Bureau stations in the surrounding territory. The lines of equal rainfall indicated that this drainage area was almost exactly in the center, as regards amount of precipitation, of a widespread storm, several surrounding towns having over 5 in. of rain, and one, only a few miles eastward, had a record of 6.48 in. These figures show that the measurement of 5.8 in. was probably very nearly correct.



Rainfall and Run-off on a Small Drainage Area Near Hartford, Conn., in October, 1911

The surveyed drainage area above the point of measurement is 1.72 sq. miles. On the night of Oct. 16 the water-level of a reservoir at the outlet of the drainage area stood at Elev. 692.3. At 3 p.m., Oct. 18, the water level had risen 6 ft., which, according to the measured capacity of the reservoir, was equal to a volume of 58,500,000 gal. At 8 a.m. the next morning the water was just at the level of the outfall—an additional volume of 22,400,000 gal. During the next 24 hr. the level rose until water was flowing over the spillway weir to a depth of 0.28 ft., indicating an inflow of 8,000,000 gal. During this whole period water was discharging through the outlet pipes at the rate of 2 cu.ft. per second.

The automatic record of the Weather Bureau station at Hartford, as well as personal observation, show that rain did not begin to fall in very appreciable amounts until about 9 a.m., Oct. 18, so it is assumed that the level of the reservoir commenced to rise at that hour. The foregoing figures, when combined and reduced, give the following rates per square mile of drainage area:

	Cu.Ft. per Sec. per Sq.Mi.
Approximate flow before rain started	1.2
Average of next 30 hours	45.0
Average of next 17 hours	29.0
Average of next 24 hours	8.0

As to the absolute maximum, no actual measurement was made, but certain conclusions may be drawn from the accompanying diagram. The period of excessive rainfall indicates, and reports of submerged highway bridges, etc., substantiate, the assumption that the maximum flow occurred about the middle of the night of Oct. 18. This assumption, with the general direction of the line of probable actual flow, as sketched in the diagram, shows a maximum, under the most conservative assumption, of over 60 cu.ft. per sec. per sq.m. of drainage area.

While the writer is aware that this figure is sometimes exceeded, particularly on such small drainage areas, and in the spring of the year, he believes that considering the geographical location and the season, when under normal conditions the ground storage is greatly depleted, this runoff is remarkably large.

Speculation as to the possible discharge under similar conditions, but with melting snow on the ground, lends emphasis, if any is necessary, to the need of ample spillways for these small drainage areas.

*14 Beacon St., Boston, Mass.

Motor-Car Engine Tests*

By J. A. Moyer†

Tests of a gasoline motor-car engine with alcohol and kerosene for fuel showed that both these fuels could be used with a carbureter arranged to be heated by the exhaust gases. Alcohol was used successfully with a carbureter heated by jacket water from the engine. In starting, however, the engine cylinder was first heated by running for a time on gasoline.

Cost of fuel per horsepower-hour with kerosene was about half that with gasoline in same engine.

Data are given of tests with gasoline of a two-cycle engine, lubricated by oil admitted with the fuel, and of an air-cooled four-cycle engine.

In view of the increasing interest taken in the use of kerosene, alcohol and other similar fuels in gasoline engines, tests were made during the past year under the author's direction in the Mechanical Engineering Laboratory of the University of Michigan by Messrs. E. M. Porter, J. S. Erskine and J. J. Seaver, students in the engineering department of the university. The tests were made to determine the relative value of kerosene and alcohol for use in gasoline automobile engines, and to investigate the effectiveness of certain types of carbureters in which the mixture is heated by exhaust gas or jacket water from the engine before being admitted to the cylinder. In making the tests, it was desired to find not only the economy of a gasoline engine operating with the other fuels, but also the effect of the use of such fuels upon general engine operation with regard to starting, operating at varying loads, etc. The results showed that an engine built for gasoline can be run very effectively on either kerosene or alcohol with very little change. The present high cost of alcohol prohibits its use as a commercial fuel, but with kerosene the cost per horsepower was found to be only about half as much as with gasoline.

The engine on which the tests were made was an Olds automobile engine of the horizontal single-cylinder design, which was used on Olds runabouts early in the past decade. The bore of the cylinder was 5 in., with a 6-in. stroke and the clearance volume in terms of per cent. of piston displacement was 32.1. The rating of this engine by the formula of the Association of Licensed Automobile Manufacturers is about 10 hp. However, as this rating is generally conceded to be too high, and as the condition of the engine, and more especially of its foundations, almost made it impossible to run the engine at 1000 ft. piston speed, its rated brake horsepower at 800 r.p.m. was computed by Güldner's formula,* which gives 6.85 hp.

The horsepower was also computed by assuming a mean effective pressure of 67½ lb. as determined from indicator diagrams, and a mechanical efficiency of 80%, using the formula $\frac{PLAN}{33{,}000}$, where P is the mean effective pressure in pounds per square inch, L is the length of the stroke in feet, A is the area of the piston in square inches, and N is the number of explosions per minute (400 at 800 r.p.m.). This formula gives 6.43 hp. In making computations for the test the rated horsepower of the engine was taken to be 6.5.

TESTS WITH KEROSENE—The tests in which kerosene was used as a fuel were made with a Blom carbureter, in which the exhaust gases from the engine are used to heat the mixture. A sectional view of this carbureter is shown in Fig. 1. Kerosene is admitted at the fuel inlet to the chamber at the top of the carbureter, from which it passes as needed into the vaporizing chamber through an opening controlled by the needle valve. The timing of fuel and air admission is obtained automatically by means of the poppet valve, whose spring is adjusted so that the valve is opened wide by the suction stroke of the engine. The main air supply for the mixture enters through the tubes leading from the vaporizing chamber to the air inlets at the lower end of the carbureter. The oil is vaporized by contact with the upper end of a heated central chamber to which the exhaust gases are admitted. From the vaporizing chamber the mixture passes through a number of openings into an annular chamber surrounding the central heated chamber, and from here it is drawn into the engine cylinder through the intake pipe.

The exhaust gases are piped to the heated chamber of the carbureter from a point in the exhaust pipe about 18 in. from the engine. From the central hot chamber they pass through a conical spiral passage to reduce their velocity, and finally pass out through the exhaust outlet, after heating, also, the air-admission tubes in the outer jacket of the carbureter. The priming opening, shown at the upper end of the carbureter, is used for admitting a fuel more easily vaporized than kerosene when starting.

In the present tests recourse was had for starting to a gasoline carbureter placed in the inlet pipe leading from the Blom carbureter to the inlet valve of the engine. It was found that the engine would not start while cold on kerosene, but when started on gasoline and run until the kerosene carbureter had become sufficiently hot, the engine ran very satisfactorily with kerosene. As a general rule, it was necessary to run the engine only about two minutes on gasoline. The average temperature of the mixture going to the engine was about 250° F., as this was the temperature at which the engine operated best. In making the tests the engine was started and run until conditions such as temperature of cooling water, engine speed, etc., had become constant, before readings were begun.

The kerosene used was that furnished by the Standard Oil Co. at a price of 7c. per gal. in barrel lots and had a lower heat value of 18,500 B.t.u. per lb. as determined by a Junkers calorimeter. The kerosene was supplied to the carbureter by means of a flexible tube about 4 ft. long attached to the fuel tank, which was placed on a platform scale reading to 0.01 lb. The mixture was led from the carbureter to the inlet valve on the opposite side of the engine through a 2-in. pipe about 3 ft. long. The air going to the carbureter was measured by a wet meter, the pressure required to overcome the resistance of the meter being supplied by a motor-driven fan. A reservoir of about 12-cu.ft. capacity was provided between the meter and the engine. Air from the reservoir was conducted to the carbureter through a 2-in. pipe 2 ft. long. A pressure of from 0.5 to 0.7 in. of water was maintained in the reservoir.

A jump-spark ignition system was used. In all the runs the spark was kept

*For previous articles on tests of gasoline engines with alcohol fuel see Engineering News, March 12, 1908, p. 271, and April 16, 1908, p. 424.

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* $\frac{n\ e\ L\ H\ d^2\ E}{108\ L}$ = b.hp. for four-cycle engines using liquid fuel, in which

n = r.p.m. (assumed here at 800);
e = Thermal efficiency (assumed here at 20%);
L = Stroke in feet;
H = Lower heating value of fuel in B.t.u. per lb. (19,100);
D = Cylinder diameter in feet;
E = Volumetric efficiency (assumed here at 70%);
L = A constant depending upon the quality of the mixture (assumed here at 250).

[See "The Design and Construction of Internal Combustion Engines," by Hugo Güldner, translated by H. Diederichs, reviewed in Engineering News (Engineering News literature supplement), Mar. 17, 1910, p. 30.—Ed.]

advanced to a point at which the engine ran at the greatest speed without "pounding." No record was made, however, of the angular lead of the spark. The output of the engine was measured by a water-cooled Prony brake applied to a pulley on a countershaft driven from the engine shaft by a chain drive with a ratio of 31 to 9 between engine speed and brake-wheel speed. By taking into account the efficiency of this chain drive, the economic results would be slightly improved. The efficiency of the drive was not, however, determined.

The results of the tests with kerosene are given in Table I. The economy obtained in the first two runs was not very good, due, perhaps, to lack of familiarity with the adjustment of the carbureter on the part of the operators. In the fourth run, however, a fuel consumption of only 0.77 lb. per b.hp.-hr. was obtained, which compares very favorably with the average consumption of gasoline in other tests. The thermal efficiency* for this run was 17.85%. The fuel consumption in the third run (0.80 lb.) was very good in consideration of the small load on the engine—less than one-half the assumed rating.

It was, however, found impossible to develop the rated horsepower of the engine when the Blom carbureter was used, 5.12 hp. being the maximum developed with kerosene. This may have been due to some fault of the carbureter, but more probably to a very low volumetric efficiency of the engine caused by the throttling effect of the passages through which the mixture traveled from the carbureter to the engine. With a more direct passage from carbureter to engine, the horsepower could probably have been increased.

TESTS WITH ALCOHOL—The alcohol tests were divided into two groups, with normal compression (corresponding to a clearance volume of 32.1%) and with high compression (clearance volume 18.25%) respectively. A third group of tests was made, in which alcohol mixed with water was used as fuel.

The alcohol used cost by the barrel 48c. per gal. Its heating value was computed from the specific gravity by means of Güldner's rule, which is as follows: Lower heat value in B.t.u. per pound is equal to 11,664 times the per cent. of alcohol by weight. Attempts were made to determine the heating value by means of a Junkers calorimeter, but these were not altogether successful. The alcohol used in runs 5 to 8 and 11 to 17, inclusive, as given in Table II, had a specific gravity of 0.836, corresponding to 80% alcohol by volume or 76.1% by weight, which gives a lower heat value of 8875 B.t.u. per lb. The alcohol used in runs 9 and 10 had a specific gravity of 0.815, which corresponds to 90% alcohol by volume or 87.7% by weight, giving a lower heat value of 10,225 B.t.u.

In runs 5 to 8 and 11 to 16, the Blom carbureter already described was used, but in runs 9, 10 and 17, a Rayfield carbureter was used, in which the mixture is heated by water from the cooling jacket of the engine. A sectional view of this carbureter is shown in Fig. 2. Fuel oil enters through the pipe at the lower part of the carbureter and passes through a strainer and regulating valve into the float chamber. From here it passes through the spray nozzle and needle valve into the mixing chamber, where the fuel is vaporized and mixed with air entering through the mechanically controlled throttle valve below and the automatic auxiliary valve at the right. From this cham-

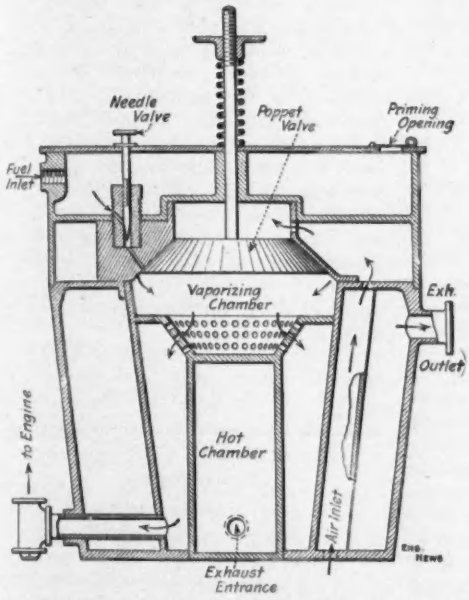

FIG. 1. SECTIONAL VIEW OF BLOM CARBURETER FOR ALCOHOL AND KEROSENE
(Vaporizing chamber heated by exhaust gas from engine)

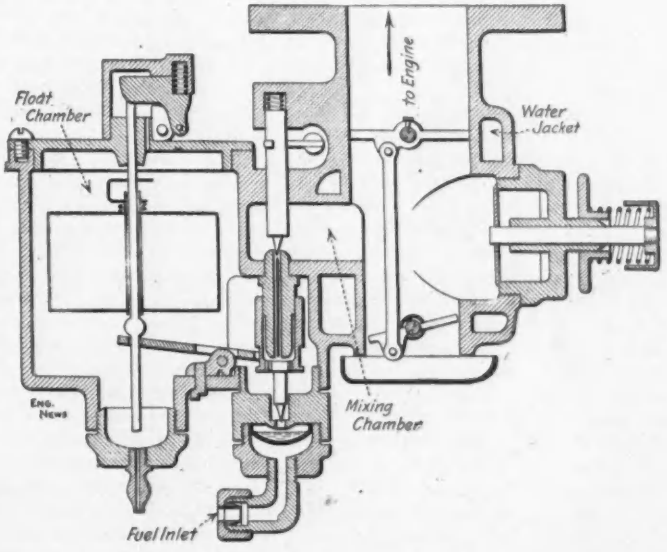

FIG. 2. SECTIONAL VIEW OF RAYFIELD CARBURETER
(Mixing chamber heated by jacket water from the engine)

*Thermal efficiencies are calculated on the basis of brake horsepower. It is the opinion of the author that too much reliance should not be placed on calculations of efficiency figured from the indicated horsepower of a high-speed gasoline engine—c.f. "Proceedings," Institution of Mechanical Engineers, July, 1909.

TABLE I. TESTS WITH KEROSENE

No.	Duration, Min.	R.p.m.	B.hp.	Fuel per B.hp.-hr., Lb.	Fuel Cost per B.hp.-hr., C'ts
1	90	562	2.05	1.24	1.30
2	30	600	3.10	0.86	0.90
3	90	630	3.39	0.80	0.84
4	80	742	5.12	0.77	0.81

TABLE II. TESTS WITH ALCOHOL

No.	Duration, Min.	R.p.m.	B.hp.	Fuel per B.hp.-hr., Lb.	Fuel Cost per B.h.p.-hr., C'ts
(a) Normal Compression					
Blom Carbureter					
5	60	583	3.22	1.56	10.70
6	60	535	4.63	1.29	8.92
7 ¾ alcohol	30	766	5.65	1.43	9.87
8 ½ alcohol	30	641	4.73	1.66	11.45
Rayfield Carbureter					
9	30	725	6.66	1.12	7.80
10	30	1020	9.45	1.16	8.02
(b) High Compression					
Blom Carbureter					
11	30	640	4.70	1.44	10.00
12	20	507	3.74	1.72	11.00
13	15	594	5.14	1.85	12.90
14	20	642	4.02	1.78	12.32
15	30	656	1.81	1.69	11.65
16	30	604	3.34	1.29	8.92
Rayfield Carbureter					
17	30	725	5.76	1.47	10.18

ber, the mixture passes to the intake pipe of the engine. In this carbureter, the vaporization is assisted by the hot water from the engine jackets circulating through the water jacket of the carbureter, which, as shown in the illustration, surrounds the mixing chamber.

The results of the tests with alcohol are given in Table II. The method of conducting these tests was in general the same as for the kerosene tests. In the tests with normal compression, the engine ran very satisfactorily with either carbureter after it was once heated. It was impossible to start the engine with alcohol until it had been warmed up by running on gasoline, except that in the case of the Rayfield carbureter it could be started by heating the carbureter with hot water. The engine was found to run very well, however, with the Rayfield carbureter at either high or low speeds without heating the carbureter at all. It was impossible to start with the engine cold, however, and it was always warmed up by running for several minutes on gasoline.

When using alcohol the point of ignition could be advanced much beyond that possible with either gasoline or kerosene, due to the fact that the flame propagation through an alcohol mixture is slower, and hence a greater lead can be given the spark without causing preignition. Less cooling water was used per brake horsepower-hour with alcohol than with either of the other fuels. Even less could have been used, as the temperature of the cooling water leaving was too low in most of the tests, and a better efficiency could, no doubt, be obtained by an increase of jacket-water temperature.

Since it may be easily shown that the efficiency of an internal-combustion engine depends upon high compression, it follows that the most advantageous degree of compression is one which is as high as possible without causing preignition. The carbon and hydrogen content of alcohol are both lower than that of gasoline, and therefore a higher compression temperature can be reached without danger of preignition. With this in mind, it was thought advisable to increase the compression of the engine to see if a better economy could not be reached. The change of compression was made by fastening an aluminum plate to the face of the piston, thus decreasing the clearance volume in terms of piston displacement from 32.1% to 18.25%.

The results obtained, as shown in Table II, were far from satisfactory, as no better efficiencies were obtained than with normal compression. It will be seen, however, from the results given in Table II that an efficiency and fuel consumption equal to that obtained at normal compression were obtained at high compression with a lower load, but as the load was increased the efficiency fell off. The minimum alcohol consumption (1.12 lb. per b.hp.-hr.) was obtained in run 9 with the Rayfield carbureter using 90% alcohol at 95% of the rated horsepower of the engine. The corresponding thermal efficiency was 22.2%, based on brake-horsepower and "low" calorific power. The mechanical efficiency of the engine is about 80%, making the thermal efficiency on the basis of indicated power approximately 28%.

Two runs, Nos. 7 and 8, were made with normal compression with 80% alcohol and water mixed together for fuel, to see what effect dilution would have on the operation of the engine. Run No. 7 was made with a mixture of three-fourths alcohol and one-fourth water, and the engine ran fairly well with this mixture after some adjustments had been made on the carbureter. In run No. 8 a mixture of one-half alcohol and one-half water was used, and it was very difficult to get the engine to operate with this fuel, but a run was finally made after considerable adjustment of the carbureter. The results of these mixture tests show that the alcohol consumption per horsepower-hour increased with increased dilution.

Tables III and IV give the results of several tests made with the Olds engine using benzine and gasoline for fuel. All of these tests were made with normal compression. An attempt was made to use gasoline with the compression increased by means of the aluminum plate on the piston as already explained, but there was so much "pounding" in the cylinder, due to preignition of the charge, that this series of tests was abandoned. The benzine used in these tests was the cheap grade sold by the oil refineries to paint manufacturers to be used as a substitute for turpentine. It is sold at about 6c. per gal. by the barrel. The specific gravity of this benzine was 0.74 and of the gasoline 0.70. These tests with benzine (Table III) were made with the Rayfield carbureter, and those given in Table IV were made using gasoline supplied to the engine through a carbureter designed for operation with kerosene; that is, one heated by engine exhaust. Cost of gasoline is calculated on a basis of 11c. per gal.

Tests of a Two-cycle and an Air-cooled Engine

In another series of tests a Gray two-cycle engine was operated with gasoline. Gas-engine oil for lubrication was mixed with the gasoline and no other means of lubrication was used. This engine has a 4-in. bore and 4-in. stroke and was operated with the carbureter supplied by the makers of the engine. Results as given in the following table are believed to be remarkably good considering that it is of the two-cycle type and that all the gas-engine oil for lubrication is included with the fuel in the weights given.

For these tests one pint of good quality of gas-engine oil was mixed with 5 gal. of gasoline. Specific gravity of the mixture was 0.73.

In road tests of automobiles, Franklin air-cooled engines have always made an enviable record for economy of gasoline, so that a comparison of laboratory results obtained with a four-cylinder Franklin four-cycle engine with cylinders of the same size as the two-cycle engine referred to above are unusually interesting.

This engine was cooled with about 120 cu.ft. of free air per horsepower-hour.

Conclusions

These tests show that the economy of a gasoline motor-car engine when provided with suitable means for vaporizing the liquid fuel is approximately the same when any of the three petroleum products—kerosene, benzine, or gasoline—is used. With alcohol used for fuel the best results, with normal compression and using a commercial gasoline carbureter, showed a fuel consumption of nearly 50% more for alcohol than for the petroleum distillates. Alcohol mixes very readily with water and it was found that such a mixture could be used to supply an engine through a gasoline carbureter. Results showed, however, that there was no reduction of actual fuel consumption as the result of using such a mixture; and on the other hand it appears that the operation of the carbureter becomes more difficult.

A comparison of the cost of operation with the various fuels shows that at the current prices benzine or a low grade of

TABLE III. TESTS WITH GASOLINE

Blom Carbureter

No.	Duration, Min.	R.p.m.	B.hp.	Fuel per B.hp.-hr., Lb.	Fuel Cost per B.hp.-hr., C'ts
18	30	610	3.30	1.18	2.26
19	30	703	5.80	0.95	1.82
20	30	794	7.80	0.89	1.70
21	20	942	9.55	1.06	2.03

TABLE IV. TESTS WITH BENZINE

(Naphtha)

Rayfield Carbureter

No.	Duration, Min.	R.p.m.	B.hp.	Fuel per B.hp.-hr., Lb.	Fuel Cost per B.hp.-hr., C'ts
22	30	590	1.48	2.63	2.63
23	30	650	3.37	1.20	1.20
24	30	768	6.28	0.95	0.95
25	30	863	7.84	0.90	0.90

TABLE V. TWO-CYCLE ENGINE WITH GAS-ENGINE OIL MIXED WITH GASOLINE

No.	R.p.m.	B.hp.	Fuel and Oil per B.hp.-hr., Lb.	Fuel Cost per B.hp.-hr., C'ts
26	408	2.15	1.56	2.91
27	800	4.92	0.96	1.80
28	1010	5.02	0.84	1.57
29	1100	5.10	0.78	1.45

TABLE VI. FOUR-CYCLE AIR-COOLED ENGINE WITH GASOLINE

No.	R.p.m.	B.hp.	Fuel per B.hp.-hr., Lb.	Fuel Cost per B.hp.-hr., C'ts
30	700	14.72	0.95	1.82
31	805	17.02	0.84	1.61
32	910	19.20	0.76	1.45
33	1000	21.85	0.72	1.38
34	1100	18.48	0.71	1.36

kerosene are probably the cheapest fuels that can be used when the fuel is to be supplied by a carbureter. Benzine has the advantage over kerosene, however, in that it can be used successfully in a float type of carbureter like Fig. 2, which for regulation has obvious advantages over the poppet-valve type shown in Fig. 1.

Results of tests given in the tables are not intended to show the maximum power of the engine. Other data not given here show that the maximum horsepower of the Olds engine operating with kerosene was only a little more than half the maximum power obtained with gasoline or alcohol. It seems probable, however, that this disparity in power developed by different fuels can be remedied by using a larger size of carbureter with kerosene.

It was observed that the amount of compression for best economy and general operation was apparently considerably less for kerosene than for gasoline, while alcohol can be used with very much higher compression than gasoline. Best values of compression for different fuels in internal-combustion engines are now being investigated at the Mechanical Laboratory of the University of Michigan.

Records of the tests tabulated show that the ordinary type of motor-car engine can be satisfactorily operated with kerosene, benzine, naphtha, gasoline or alcohol. With a well designed gasoline carbureter, benzine can be used without any difficulty whatever except probably in cold weather. When the temperature of the air is not lower than 50° F. no preheating is necessary. While kerosene and alcohol can be used in carbureters heated by exhaust gases or by hot cooling water from the engine jackets, it is yet necessary to provide special devices for starting, as, for example, a means for temporarily supplying gasoline for a few minutes, or else a torch must be used for independently heating the carbureter till the engine can supply the heat required.

The tests of the two-cycle gasoline engine are included here because the performance is exceptionally good and the data given regarding the method of lubrication described are needed.

Except for the difficulty in starting and the greater cost of fuel, alcohol is particularly suitable for operating air-cooled engines, because in such engines, when using alcohol, the cylinders can be at a much higher temperature without preignition troubles than with gasoline.

Gasoline-Electric Omnibuses are to be put into use in London, according to the London "Times," to the number of 150 by the end of 1912. A demonstration car, exhibited by the makers, had a four-cylinder engine direct-connected through a flat leaf spring to a 25-kw. generator to be run at from 350 to 1400 r.p.m., giving a maximum voltage of 400. A controller box is provided with a reversing switch and a shunt resistance for the generator fields, but on level roads and light grades the car is controlled through the engine throttle.

Contract Prices and Cost of Work on the New York State Barge Canal*.

The following table shows the contract prices for the larger items of work under contract. This table shows rather large variations in prices bid for various classes of work. It should be remembered that the first contracts were let in 1905 and that bids have been received several times every year since that date. This covers at least one rather severe financial depression and two periods of increased cost of work.

The cost of excavation per cubic yard, including depreciation, interest and overhead charges, has been as follows:

*From a paper by Wm. B. Landreth, M. Am. Soc. C. E., in the "Journal of the Association of Engineering Societies" for September.

Earth Excavation

By hydraulic dredge	from $0.05 to $0.16
By dipper dredge	0.13 to 0.30
By ladder dredge	0.15 to 0.25
By clamshell dredge	0.09 to 0.15
By revolving excavators and scraper bucket	0.05 to 0.28
By towers and scraper buckets	0.11 to 0.20
By steam shovel	0.10 to 0.40
By graders	0.14 to 0.30
By hand and team	0.14 to 0.60

Rock Excavation

Dry rock by steam shovel	$0.30 to $0.75
Dry rock by hand and derrick	2.00 (average)
Wet rock	1.00 to 2.25

Channeling has cost from 22c. to 38c. per sq.ft., depending on the character of the rock, the rock channeled having varied from soft badly broken shale and slate to hard limestone.

The cost for second-class concrete has been from $4.20 to $7 per cu.yd. in place, including depreciation, interest and overhead charges.

Contract Prices

Contract No.	Excavation Nature	Excavation Price	Embankment	Concrete First	Concrete Second	Concrete Third	Concrete Washwall
1	dry and wet	$0.57½	$0.11½	$7.75	$6.75	$5.85	$1.90
2	dry	0.40	0.12	6.50	5.50	4.50	1.50
2–E		0.54	0.15	0	6.25	0	2.00
3	dry	0.41	0.12	6.65	6.15	5.25	1.50
4		0.14	0.08½	0	5.20	0	2.12
5	dry and wet	0.12½	0.09½		5.65	5.25	2.35
6	dry	0.46½	0.15	0	5.25	4.90	0.80
8		0.60	0.15	0	7.00	6.00	0
9		0.50	0.17	0	6.75	6.25	2.50
10		0.86	0.15	8.00	6.40	0	2.00
11	dry	0.51	1st Cl. 0.10		5.00	0	2.00
			2d Cl. 0.05	0			
12	Div. 1.—Wet	1.89					
	Div. 2.—Dry	0.561	0.165	0	7.15	0	2.75
	Div. 3.—Dry and wet	0.308					
	Div. 4.—Dry and wet	0.187					
14	dry and wet	0.735	1st Cl. 8.00				
			2d Cl. 0.11	8.00	7.50	6.50	2.50
15	dry and wet	0.285	0.175	0	6.00	0	2.25
17*		0.96	0.12	0	6.50	6.30	1.50
17		0.96	0.12	0	6.86	6.30	1.50
18		0.52	0.15	0	6.25	0	1.50
19		0.60					
		0.17½	0.14	0	6.40	0	1.35
20–A	wet	0.80	0.18	0	0	0	2.40
20–B	wet	0.638	0.16½	0	0	0	2.20
20–C	wet	0.51	0.18	0	0	0	0
20–D	wet	0.51	0.18	0	12.00	0	12.00
21		0.48	0.15	0	7.00	0	1.75
23		0.28	0.04	0	6.40	0	2.00
24							
25	dry and wet	0.23	0.10	0	5.75	0	1.80
26	wet	0.34½	0	0	0	0	0
27	wet and dry	0.26	0.15	0	6.50	0	2.00
29		0.22½	0.09	0	6.50	0	2.10
30		0.3375	0.15	0	6.50	6.50	2.00
31		1.25	0.14	0	5.90	0	0
33		0	0	0	9.50	0	0
35		1.14½	0.12½	0	7.20	0	0
37	wet	1.74	0.18	0	6.50	0	2.00
38		0.50	0	0	7.00	6.50	0
39	wet	0.83	0	0	7.50	0	2.45
40	dry and wet	0.78	0.15	0	7.00	6.30	2.50
41		0.22	0.04	0	10.00	0	0
42		0.19	0.11	0	6.00	0	2.00
43	dry and wet	0.18	0.08	0	6.00	0	1.75
44		0.20½	0.08	0	6.50	0	1.85
45	dry	0.42	0.15	8.00	6.75	0	2.00
46	dry and wet	0.17	0.10	0	6.25	0	0
47	dry and wet	0.199	0.15	0	6.10	0	0
49		0.23	0.15	0	5.60	0	1.75
50		0.46	0.28	0	6.00	5.00	0
53		0.75	0.15	0	6.35	0	0
54		0.36	0.18	0	6.40	0	2.50
55		0.65	0.18	0	7.00	0	2.00
60		0.53	1st Cl. 0.18				
			2d Cl. 0.14	0	9.00	7.80	2.50
61		0.60	1st Cl. 0.15				
			2d Cl. 0.12	8.00	7.50	6.00	2.50
62	wet and dry	0.64	0.21½	0	7.50	6.75	2.00
63		0.33	(dry) 0.18	0	7.00	6.00	2.50
64		0.58	1st Cl. 0.18				
			2d Cl. 0.14	0	9.00	7.80	2.50
66		0.497	1st Cl. 0.18				
			2d Cl. 0.14	0	9.00	7.80	2.50
67		1.45	0.15	0	6.25	0	0
68		0.75	(wet) 0.05				
			(dry) 0.12	0	6.25	0	2.50
69		0.85	0.18	0	6.25	0	0
70	wet	0.99	0.15	0	7.00	0	2.25
71	wet and dry	2.00	0.15	0	7.00	0	2.50
72		1.24	0	0	0	0	0
73	wet	0.52	(wet) 0.15	0	7.00	0	2.50
75		0	0	0	11.00	0	0
78	wet	0.19½	0.14	0	7.00	0	2.15
79		1.00	0	0	8.00	0	0
27–A	wet and dry	†0.198					
		0.44	0.165	0	7.70	0	2.20
90		0.45	0.30	0	8.50	0	0

*Relet. †Excavation from spoil banks.

An Investigation of Creosoted Wood Paving Blocks After 9½ Years Service

The character of creosote oil most suitable for the treatment of wood paving blocks has been a subject of discussion by engineers and others for some time past,* and some investigation on this line has been made by examining blocks which have been in service in Chicago for about 9½ years. These blocks were in a short stretch of paving on Michigan Ave., in front of the Auditorium Hotel. They were removed in 1909, not because of any defect but because asphalt-concrete paving was to be laid upon this street. (ENGINEERING NEWS, Oct. 21, 1909, p. 435.) The blocks were stored in Grant Park, where the samples used for test were obtained. The investigation was made by direction of A. J. Hammond,† M. Am. Soc. C. E., as chief engineer of the Chicago Bureau of Public Efficiency. In reply to inquiry, he writes us as follows, and we give also an extract from the report submitted to him by J. H. Howard, of New York, who made the analyses.

MR. HAMMOND—These blocks had been in the pavement for about 9½ years, had given good service and were in good physical condition when removed. They were removed so that a pavement of uniform character might be laid on the avenue. The purpose of the investigation was to find out the characteristics of the creosote oil used for the preservation of the block (whether it was a pure coal-tar creosote); also to determine the amount of oil used per cubic foot of timber remaining in the block, and the character of this oil.

In general the purpose of the investigation was to show that yellow pine treated with pure creosote oil having a specific gravity of 1.06 to 1.08 and impregnated with about 16 lb. per cu.ft. makes a very satisfactory pavement. The further fact that so large a percentage of the oil remains after 9½ years proves that it is unnecessary to load the creosote oil with coal-tar pitch to such an extent as to raise its specific gravity to 1.14 or make use of coal tar to such an extent as has been the practice for the last year or two. The investigation, in my judgment, confirms the conclusion drawn in my report to the Chicago Bureau of Public Efficiency* that pure creosote oil has superior qualities for the preservation and treatment of wood blocks over the higher gravity oil.

REPORT OF MR. HOWARD—The wood is a good grade of long-leaf yellow pine. The blocks were very well preserved and showed practically no appreciable amount of wear and no decay. The blocks still contained 14.5 lb. per cu.ft. of the preservative. The records showed that the original content of the block was 16 lb. The loss of preservative, therefore, was only 1.5 lb. per cu.ft. in 9½ years. This was the very lightest portion of the preservative and did not materially injure the quality of the blocks in respect to resisting decay, nor detract from the physical or wearing qualities as against weather and traffic.

The fractional distillation of the extracted preservatives gave a total up to 315° C., 41.1%; 315° and over, 54%; residue, 4.9%. A second or check distillation on another sample of extracted preservative showed that the distillate up to 315° C. is 46%.

The specific gravity of the extracted preservative is 1.08. The specific gravity of the original preservative, which was a creosote oil made from coal tar, I estimate was between 1.03 and 1.05, which confirms certain records of past years, indicating that the gravity of the original coal-tar creosote used in the above pavement was 1.06. As for the natural resin of the wood, I was careful to exclude that from the distillation tests up to 315° C. A little of the resin appears in the distillate above 315° Centigrade.

The long and successful use of the good yellow-pine creosoted blocks on Michigan Avenue proves that such wood blocks treated with creosote oil of a gravity of 1.06 or a little lighter gravity and an oil which, when new, yielded (by fractional distillation up to 315° C.) between 50 and 75%, and after 9½ years a distillate of 46%, made a successful, durable pavement under severe climatic conditions and heavy city traffic.

*See Engineering News, April 27 (p. 501), and Aug. 31, 1911 (p. 254).

†Consulting engineer, South Bend, Ind.

*Engineering News, Aug. 31, 1911.

Extension of Track Pans on the Pennsylvania R.R.—The recent decision of the operating department of the Pennsylvania R.R. to use four engines instead of three on eastbound trains between Conemaugh, Penn., and Gallitzin has made it necessary to increase the length of the track pans in the two eastbound tracks at Wilmore from 1800 ft. to 2600 ft., and the work of extending these pans is now under way. This water station is located 11 miles east of Conemaugh and 12 miles west of the summit of the heavy grade against eastbound trains rising from Conemaugh. It is propably the largest individual water station in the country, as over 2,250,000 gal. of water are used there daily.

In this connection it is interesting to note the provision which it is necessary to make to allow locomotives to take water on this exceedingly busy four-track line. Two alternate plans are in use at different points on the part of the line in question. At some places track pans are provided so that the trains will take water while in motion; or they may be brought to a stop and supplied with water from standpipes. However, the stopping of a train on the main line long enough for four engines to take water from standpipes will ordinarily result in tying up several other trains behind it and soon blocking the line. For this reason when water is taken from standpipes it becomes necessary to construct several sidings on which freight trains can head in and several trains take water at the same time. At Denholm on the Middle division and Thorndale on the Philadelphia division, both of which points are also coaling stations, such a plant has been adopted, 12 side tracks being provided, on which as many trains can take water at the same time.—"Railway Age-Gazette," Dec. 22.

Notes from Engineering Schools

MASSACHUSETTS INSTITUTE OF TECHNOLOGY—Prof. C. H. Peabody, head of the Department of Naval Architecture, has announced that funds have been subscribed by Clinton H. Crane and Arthur T. James, of New York City, for the continuance of experiments with model boats of tugboat size. This work has been carried on for two years with a model ship made according to the plan of the U. S. Revenue Cutter "Manning." This little boat, the "Froude," is one-fifth the size of the larger vessel. It was fitted with a gasoline-electric generating set to drive a motor, chain-connected to the propeller shaft. The vessel is equipped with various instruments for studying performance. The first year's experiments in the Charles River basin, at Boston, were undertaken to see what could be done with the boat and what was beyond the scope of such trials. The second season's experiments have been with propellers. These two seasons' work were made possible by the late Dr. C. G. Wells, of Boston. It was thought at first that his death prevented a continuance of the studies, but the new fund now announced enables the work to be carried along. It is expected that a new hull will be built and equipped with the machinery at present on the "Froude."

Engineering News of the Week

An International Engineering and machinery exhibition will be held at the Olympia, London, England, Oct. 4-26, 1912.

A Boiler Exploded, Dec. 21, in a sawmill, at Apiary, Ore., wrecking the mill building. Two men were killed and two others injured.

A Powder Mill Explosion, Dec. 22, destroyed the mixing room of the Canadian Explosive Co.'s plant at Departure Bay, near Nanaimo, B. C. Reports state that three men were killed and a number of others injured.

An Association of Men Interested in divining-rod practice was formed recently at the meeting of interested persons at Hannover, Germany. The meeting was called by Mr. G. Franzius, of the German Navy, who for a number of years past has actively promoted the divining-rod in German literature. The new association is known as the "Verband zur Klärung der Wünschelrutenfrage." Among the members of the executive council of the organization are Mr. Franzius and Prof. R. Weyrauch, professor of hydraulics at the Stuttgart Technical College. Prof. Weyrauch is acting as secretary. The association expects to put forth occasional publications. One pamphlet has already appeared; it tells of the work of Mr. von Uslar in Southwest Africa, where he apparently conducted extensive water-finding work.

A Permanent Railway Exhibit of railway supplies and equipment is to be maintained in Chicago for the use and benefit of manufacturers and railway officers. It will occupy an entire floor of the new Karpen Building, 900 So. Michigan Ave., which floor has some 26,000 sq.ft. of space available for booths of exhibitors. There will be also a secretary's office, committee rooms, and an assembly hall with accommodation for 250 persons. This hall will be placed at the disposal of associations of railway men and supply men, for holding their meetings. There will be no partitions in the exhibit space, but the booths will be separated by bronze railings and a uniform design of numbers and signs will be used. Electric light is provided, and power is available for the operation of models and machinery. A number of booths have been rented, and it is expected that the exhibition will soon be ready for the opening. The secretary is Francis H. Quail, Karpen Building, Chicago.

The Proposed Building Code for New York City once more failed of passage in the Board of Aldermen, on Dec. 29, 1911, by a vote of 39 against to 34 for. The effort to promulgate a new and revised building code for the city dates back for about seven years, during which time it has engaged the attention of a fixed committee of the Board of Aldermen and the expensive consultation of a number of experts. After vigorous opposition, particularly on the part of the representatives of the concrete industries, who claimed that their material was legislated against by the revision, the code was passed by a vote of 40 to 38 on July 13, 1909, only to be vetoed by Mayor McClellan. The present revision, according to its backers, had eliminated from it the objectionable features of the vetoed code, but nevertheless, was opposed by the same interests who opposed the earlier revision. It was advocated, however, by the Tammany members of the Board of Aldermen and the final vote against it was taken on the last day those members held a majority of the Board. The vote was mainly divided on political lines, but the code failed of passage on account of several desertions from the Tammany fold. It seems probable now that the code, in its present form at least, will not be brought before the Board for some time.

An Additional Water Supply for Yonkers, N. Y., has been reported on by Hazen & Whipple, New York City. The present works, which are owned by the city, supply surface water from Saw Mill River and Grassy Sprain Reservoir, and yield about 8,500,000 gal. a day in a dry year. The present consumption is about equal to this yield and is increasing. The engineers suggest increasing the supply from the present sources to the economical limit of storage, which would yield 18,000,000 gal. a day in a dry year and in other years some 20,000,000 gal. or more. It is estimated that this would afford a sufficient supply until 1927, at an estimated construction cost of $2,100,000 for filters, pumps and structures, and a possible $1,000,000 additional for 700 acres of land. As to the quality of the proposed new supply, the engineers state.

It is to be noted that the present practice of using raw river water in the filters, as well as the use of unfiltered water from Grassy Sprain Reservoir, is to be entirely discontinued, and that all water will be filtered and only water which has been for a considerable period of time in storage will be taken to the filters. It is proposed to operate the filters at a rate of 5,000,000 or 6,000,000 gal. per acre daily, because it is believed that all the requirements can be met by these rates in connection with the other agencies of purification. It is proposed further to continue the present system of adding hypochlorite of lime to the effluent. It is proposed further to install a resident chemist and bacteriologist, with laboratory facilities, whose sole business it will be to study the conditions of water supply and to manage the plant so as to give the best quality of output that can be obtained. Certainly with these conditions the present quality of output may be maintained with more than double the amount of pollution now entering the water.

A New Water Supply for Charleston, S. C., under municpal ownership, was reported on by Rudolph Hering, New York City, in the fall of 1911. On the supposition that the existing pumps, mechanical filters and distributing system of the Charleston Water & Light Co. would be utilized, and that the water of the Edisto River would be substituted for the present Goose Creek supply, Mr. Hering made a preliminary layout and estimate of cost. This would involve a 10,000,000-gal. pumping plant at Givhan's Ferry, working against a total head of 63 ft.; a small fuel-oil pumping station, a 4-in. oil-pipe line 40,000 ft. long, and oil-storage tanks; and a 36-in. continuous wood-stave pipe line, 23.3 miles long, with a daily capacity of 10,000,000 gal., leading from the new pumping station to the old works on Goose Creek. The tentative estimated cost of these works is $682,500. Rough estimates of an alternative plan, involving a complete system of works, and omitting all parts of the existing supply and distribution systems, place the total cost at $2,016,000, exclusive of land. So far as we are informed, no definite steps to carry out either plan have been taken by the city. As many of our readers know, John M. Diven is superintendent of the Charleston Light & Water Co., the owner of the water-works which now supplies Charleston. The water company has in mind to increase the present Goose Creek supply by obtaining an additional quantity of water from the Ashley River.

Personals

Mr. Leonard A. Busby has been elected President of the Chicago City Railway Co., succeeding Mr. Thomas E. Mitten, resigned.

Mr. J. R. Hoffert, formerly of the Pennsylvania Department of Health, has been appointed Assistant Superintendent of Parks of Harrisburg, Penn.

Mr. Gaylord C. Cummin has been appointed City Engineer of Dayton, Ohio. Mr. Cummin is at present in charge of an irrigation project in Texas.

Mr. W. T. Wooley, formerly Engineer of the Public Improvement Commission of Hoosick Falls, N. Y., has been appointed City Engineer of Schnectady, N. Y.

Mr. Harry J. Deutschbein, Jun. Am. Soc. C. E., formerly Superintendent of Water Works of Albany, N. Y., has accepted a position with the Foundation Co., of New York City.

Mr. James S. Lyman, of Pittsfield, Mass., a former chairman of the Democratic State Committee, has been nominated by Governor Foss to be a member of the Massachusetts State Highway Commission, succeeding Mr. Harold Parker, M. Am. Soc. C. E., resigned.

Mr. Duncan W. Peck, of Syracuse, N. Y., formerly Assistant State Superintendent of Public Works of New York, has been appointed Superintendent of the same, succeeding Mr. Chas. E. Treman, who has resigned to engage in private business. Mr. Peck's salary will be $6000 per annum.

Mr. Frank C. Wilkinson, Division Superintendent of the Bay State Street Ry. Co., of Lynn, Mass., has resigned after 33 years of continuous service with street railway companies. He was a driver of a horse car until the event of the electric car, when he became a motorman.

Mr. Theodore P. Shonts, President of the Interborough Rapid Transit Co., which operates the elevated and subway lines in the Boroughs of Manhattan and Bronx, New York City, has been elected President of the New York Railways Co., successor to the Metropolitan Street Ry. Co., which has been in the hands of a receiver for the past few years. Mr. Frank Hedley, Vice-President and General Manager of the Interborough Rapid Transit Co., becomes also Vice-President of New York Railways Co., in charge of maintenance-of-way and equipment; Mr. D. W. Ross is Vice-President in charge of contracts and supplies. Mr. George H. Pegram, M. Am. Soc. C. E., Chief Engineer of the Interborough, is appointed Chief Engineer of the new company also; Mr. H. G. Stott, M. Am. Inst. E. E., Superintendent of Motive Power of the Interborough, has his authority extended over the surface lines of the new company, and Mr. J. S. Doyle is Superintendent of Power Equipment. The New York Railways Co. is incorporated with a capital of $17,500,000, and will operate a large part of the surface lines in Manhattan.

Mr. J. T. Wallace, Superintendent of the West Jersey & Sea Shore R.R., at Camden, N. J., has been appointed General Superintendent of Motive Power of the Pennsylvania R.R., succeeding the late R. N. Durborow. Mr. James Buckelew, formerly Division Superintendent of the Pennsylvania R.R., at Oil City, Penn., has been appointed Superintendent at Camden, N. J., of the Camden Terminal; Mr. Victor Wierman, Division Superintendent at Camden, has his authority extended to cover both the Amboy and Belvidere divisions, which have been combined to form the Trenton division; Mr. A. P. Gest, formerly Division Superintendent at Trenton, N. J., has been appointed Special Agent of the New Jersey division; Mr. C. S. Krick, Superintendent of the Terminal division at New York City, has had his authority extended over the Hudson division; the two divisions are combined into the Manhattan division; Mr. A. M. Parker, formerly Superintendent of the Hudson division, has been appointed Superintendent of the Allegheny division; Mr. H. S. Hayward, formerly Superintendent of Motive Power of the New Jersey division, has been appointed Consulting Engineer of floating equipment; Mr. D. M. Perine, Superintendent of Motive Power of the West Pennsylvania division at Pittsburgh, Penn., has been appointed Superintendent of Motive Power of the New Jersey division at Camden, N. J., and Mr. J. M. James, Master Mechanic of the West Philadelphia shops, has been promoted to Superintendent of Motive Power of the West Pennsylvania division, at Pittsburgh.

Obituary

C. H. Palmer, for a number of years President of the Butte & Boston Mining Co., of Butte, Mont., and once prominent as a civil and mining engineer, died on Dec. 27, at Atlantic City, N. J.

Edward Sawyer, one of the oldest members of the Boston Society of Civil Engineers, and once prominent as a hydraulic and municipal engineer throughout New England, died at his home in Boston, Mass., on Dec. 27, aged 73 years.

Augustus Porter Barnard, a graduate of the Columbia University School of Mines, and for many years in the service of the United States Coast and Geodetic Survey, died in St. Luke's Hospital, New York City, on Dec. 26, from pneumonia. He was born in New Orleans, La., on Mar. 30, 1847, and was the eldest son of the late Gen. John G. Barnard, U. S. A. He was a nephew of the late Dr. F. A. P. Barnard, President of Columbia University and founder of the Barnard College for women.

William Dalton Clark, once prominent as a civil engineer, died at his home in Springfield, Ohio, on Nov. 9, at the advanced age of 91 years. He was born in New Boston, N. H., in 1820. His early education was received at the intermittent sessions of a country school and in two terms at an academy in a neighboring town. In 1847, after some years on the farm and two years as a schoolmaster, he entered a civil engineer's office in Lowell, Mass. Some time later he removed to Nashua, N. H., and entered practice as a civil engineer and architect. In 1856, he removed to Davenport, Iowa, and became associated with Stone, Boomer & Boyington, Bridge Builders. Eight years later he was elected City Engineer of Davenport. In 1868 he was Assistant Superintendent of Construction of the State Capitol at Springfield, and in 1872 he became City Engineer of Springfield, continuing in that position until 1881, when he was appointed Superintendent of Construction of the Arapahoe County Court House in Denver, Colo. The following year he was given charge of construction of the State Capitol of Texas at Austin. After a year's service here, he resigned because of ill-health and returned to his home in Springfield, Ill., where he passed the remainder of his life. He is survived by one son and one married daughter.

Engineering Societies

COMING MEETINGS.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
Jan. 6. Annual meeting at Seattle, Wash. Secy., Joseph Jacobs, 503 Central Bldg., Seattle, Wash.

AMERICAN SOCIETY OF ENGINEERING CONTRACTORS.
Jan. 9. Annual meeting at New York City. Secy., J. R. Wemlinger, 13 Park Row, New York City.

MINING AND METALLURGICAL SOCIETY OF AMERICA.
Jan. 9. Annual meeting at New York City. Secy., W. R. Ingalls, 505 Pearl St., New York City.

MICHIGAN ENGINEERING SOCIETY.
Jan. 9-11. Annual meeting at Lansing, Mich. Secy., Alba L. Holmes, 574 Wealthy Ave., Grand Rapids, Mich.

NEW ENGLAND WATER WORKS ASSOCIATION.
Jan. 10. Annual meeting at Boston, Mass. Secy., Willard Kent, 715 Tremont Temple, Boston, Mass.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.
Jan. 16. Annual meeting at Pittsburg, Penn. Secy., Elmer K. Hiles, 3511 Oliver Bldg., Pittsburg, Penn.

WOOD PRESERVERS' ASSOCIATION.
Jan. 16-18. Annual convention at Chicago, Ill. Secy., F. J. Angier, Mount Royal Station, Baltimore, Md.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 17-18. Annual meeting at New York. City. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 17-19. Annual meeting at Urbana, Ill. Secy., E. E. R. Tratman, 1138 Monadnock Block, Chicago, Ill.

SOCIETY OF AUTOMOBILE ENGINEERS.
Jan. 18-20. Annual meeting at New York City. Secy., Coker F. Clarkson, 1451 Broadway, New York City.

KANSAS ENGINEERING SOCIETY.
Jan. 23-24. Annual meeting at Manhattan, Kan. Secy., W. S. Gearhart, Manhattan, Kan.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 23-25. Annual meeting at New York City. Secy., W. W. Macon, 29 West 39th St., New York City.

OHIO ENGINEERING SOCIETY.
Jan. 24-26. Annual meeting at Cleveland, Ohio. Secy., Clyde J. Knisely, New Philadelphia, Ohio.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 24-26. Annual meeting at Montreal, Que. Secy., C. H. McLeod, 413 Dorchester St., West Montreal, Que.

INDIANA ENGINEERING SOCIETY.
Jan. 25-27. Annual meeting at Indianapolis, Ind. Secy., Charles Brossman, Union Trust Bldg., Indianapolis, Ind.

NEW ENGLAND ASSOCIATION OF GAS ENGINEERS.
Feb. 14-15. Annual meeting at Boston, Mass. Secy., N. W. Gifford, 26 Central Square, East Boston, Mass.

IOWA ENGINEERING SOCIETY.
Feb. 21-23. Annual meeting at Davenport, Iowa. Secy., S. M. Woodward, Iowa City, Iowa.

NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Mar. 6-9. Annual convention at Chicago, Ill. Secy., T. A. Randall, Indianapolis, Ind.

Wisconsin Electrical Association

The third annual meeting will be held in the Pfister Hotel, at Milwaukee, Wis., Jan. 18-19. The secretary is George Allison, Stevenson Bldg., Milwaukee, Wis.

New England Water Works Association

The program for the annual meeting at the Hotel Brunswick, Boston, Mass., Jan. 10, includes the following committee reports: "Conservation of the Natural Resources of the Country," M. N. Baker; "Standard Specifications for Fire Hydrants," H. O. Lacount; "Uniformity of Hose and Gate Nuts," Frank L. Fuller; "Water Consumption Statistics," Leonard Metcalf; "Low Water Yields of Catchment Areas in New England," Frederick P. Stearns. The names given are those of the committee chairmen.

The American Society of Civil Engineers

Three special meetings will be held on Friday and Saturday, Jan. 19 and 20, at the house of the Society in New York City for the discussion of road construction and maintenance. At the first meeting on Friday at 10:00 a.m., two divisions of the subject will be discussed: (1) "Drainage and Foundation," discussion opened by James Owen; (2) "Fillers for Brick and Block Pavement," discussion opened by Geo. W. Tillson.

The second meeting will be held Friday at 2:00 p.m., and the topic for discussion will be "Bituminous Surfaces." The discussion on this topic will be opened by A. W. Bean.

At the third meeting at 10:00 a.m., on Saturday, Jan. 20, the topic for discussion will be "The Use of Bituminous Materials in Penetration and Mixing Methods." The discussion will be introduced by Linn White. All engineers, whether members of the Society or not, are invited to attend these meetings.

Brooklyn Engineers Club

A prize of $15 in cash has been established for the most valuable paper presented by a member during each year. The prize is known as the Alfred T. White prize, after the donor. Mr. White, a graduate of Rensselaer Polytechnic Institute, is one of Brooklyn's first citizens and a well known philanthropist. He was Commissioner of City Works in Brooklyn in 1894 to 1895, and has been an honorary member of the Brooklyn Engineers Club since the first year of its existence.

The first award of the Alfred T. White prize will be made at the end of the year 1912, and the first paper which will be given consideration in the award of the prize will be the one presented at the meeting of Jan. 11, 1912. The award will be made by a committee of three members, to be appointed by the president at the beginning of each year. Only members of the club in good standing will be eligible to receive the prize. In making the award the committee will give consideration to (1) contribution to engineering knowledge; (2) literary merits; (3) delivery. The members of the committee appointed for the coming year by President Wm. T. Donnelly are as follows: Arthur S. Tuttle, chairman; J. S. Langthorn and William W. Macon.

American Institute of Electrical Engineers

The present plan of nominating officers is to be slightly modified by a new by-law adopted by the Board of Directors, Dec. 8, 1911. By the old plan, officers are nominated and elected as follows: Nomination blanks are mailed to members early in February; the filled forms are returned to the Institute office and examined by a committee of tellers which tabulates the nominations and reports to the Board of Directors; then a "Director's Ticket" is made up and sent out on a ballot; these ballots contain, besides the "Director's Ticket," the names of all candidates for the various offices, who have received at least 3% of the total nomination vote.

There have been several objections to this procedure. For instance, there is no official way in which a group of members may recommend a candidate to the entire membership. Also, the majority have no way of knowing whether or not eligible men are willing to accept election. In the past, suggestions for candidates have been made through circular letters.

Any radical change in method of nomination and election requires an amendment to the Constitution. Amendments have been difficult to secure in the Institute, and in this case an amended by-law sufficed to bring about the change. This did not require action by the membership. The addition to the present system consists merely in publishing, at the time the nominating ballots go to the members, the names of all candidates in favor of whom a petition of 50 names, or the separate indorsement of 50 names has been received at the Institute headquarters by Jan. 25.

Engineering News

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Changes and Operating Results at the Coagulation and Sedimentation Plant of the Water-Works of St. Louis, Mo.

By Edward E. Wall*

More than seven years ago the process of clarifying and purifying the water supply of the city of St. Louis by coagulation and continuous sedimentation was inaugurated. Its evolution through the intervening years has been most interesting to those engaged in it, as difficulty after difficulty has been met and more or less successfully overcome. The results to the people of St. Louis have been most gratifying, although they could but imperfectly appreciate the magnitude of the problem, and could realize still less many of the greater and almost all of the smaller blessings which pure water brought to them. To them the greatest boon came from the delight of having an abundance of clear water for the table and the bath, and from the satisfaction of using clean water to make all things clean. The larger benefits arising from its effect on the public health and from its commercial uses passed by almost unnoticed. Today they have almost forgotten that they ever had any other than clear water.

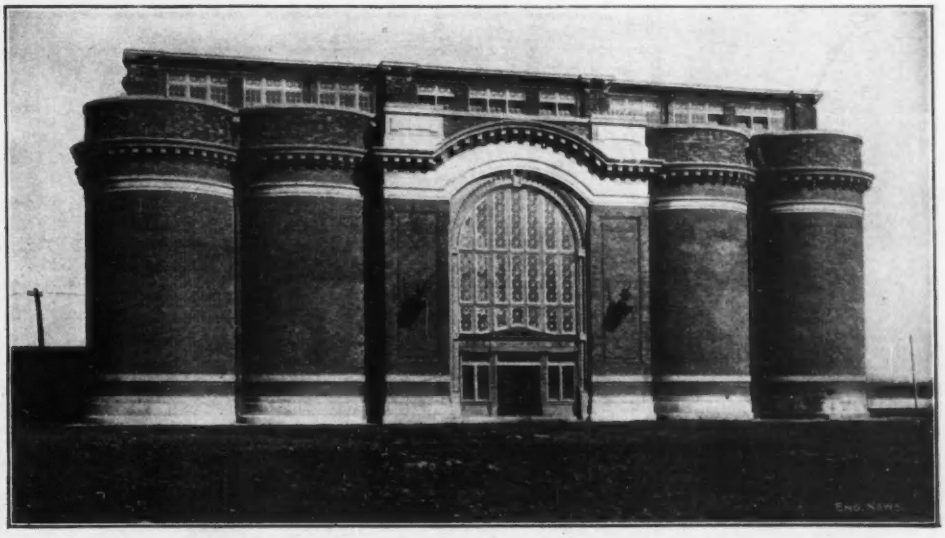
Changes in the Settling Basins

On Nov. 26, 1903, Engineering News published an article [by Mr. Wall] on, "Changes in the Settling Basins and the New Hydraulic Dredge of the St. Louis Water-works," in which proposed changes in the basins were fully described. In order that the reader may see how nearly those plans were carried out, Fig. 1 from that article is herewith reproduced. The differences between the basins as they now exist and as they are shown in Fig. 1 are explained in the subtitle to the illustration.

The present operation is as follows: The river water, charged with coagulants, enters Basin 1 through the four gates, flows through the series of basins from 1 to 6, over the weirs, which are usually submerged, so that the water surface in Basin 6 is practically the same as in Basin 1; thence from Basin 6 to Basin 7 through a 4x8-ft. conduit and on to Basin 8 over the dividing wall. It is then drawn from Basin 8 into the drawing conduit through the gate at the outer corner of the basin. Probably 90% of the sediment falls in Basin 1, necessitating its being cleaned after from four to eight weeks' service, depending upon the muddiness of the river water during the time.

When it becomes necessary to clean Basin 1 the water in the series of Basins 1 to 6 is lowered until the dividing wall between Basins 1 and 2 is exposed. The water is then introduced into Basin 6 from the filling conduit and flows through Basins 5, 4 and 3 into 2, whence it can be drawn directly into the drawing conduit or it may be drawn through the bypass into Basins 7 and 8 as before. Basin 1 is then emptied, cleaned and put in service, the flow from Basin 1 to Basin 8 being through the 84-in. steel-pipe line, and the supply drawn out through the farther gate in Basin 7. When Basin 6 is cleaned the water is drawn down to the level of each weir in Basins 1 to 6, the raw water being again introduced into Basin 1, temporarily throwing Basins 7 and 8 out of service. This is the weak point of the system, and it is now intended to change the basins to get away from the difficulties incident to this condition.

It is proposed to divide Basin 8 into two basins, 8 and 9, each 400x400 ft.; and to extend the inlet from the 84-in. pipe at the outer corner across the basin so as to introduce the coagulated water into Basin 9 in a similar manner to that now used at Basin 1.



West Front of Coagulant Storage and Mixing House for the Water-works of St. Louis, Mo.

(Four large storage bins at either end. Mixing room in center.)

After a basin has been in service a few days, it is the practice to open the sewer gate a short time each day to flush out the sediment, thus increasing the length of time it can be kept in service.

Basin 9 will have two connections to the sewer inside the basin, spaced so that sediment may be washed out from a considerable area. These outlets will be controlled by valves operated from stands above the water, located on steel towers. The wall between Basins 5 and 6 will be raised 2 ft. to avoid the necessity of lowering the water level when Basin 6 has been emptied. The wall between Basins 1 and 2 will be lowered 1 ft., so that the head necessary in Basin 9 to force the flow through Basins 7, 6, 5, 4,

*Water Commissioner, St. Louis, Mo.